Science, Technology and Innovation

The White Paper

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Preface by the Minister for Commerce, Science and Technology

Science and Technology (S&T) and the Policy Process

In the abstract, policy formation involves a process of philosophical debate, policy analysis, public consultation and examination of the practical implications before moving to decision and finally to implementation. In the world of government, before proceeding to implementation, debate and consultation are sometimes achieved through the 'Green Paper' process. Concrete decisions are then normally translated into a White Paper, usually the precursor to the final stage of implementation and, perhaps, legislation.

The debate that preceded this White Paper can trace its origins to the National Economic and Social Council (NESC) and two economic reports in 1992 and 1993 (Lars Mjoset's *The Irish Economy in a Comparative Institutional Perspective* and the Council's *Strategy for Competitiveness, Growth and Employment*). This led to the stage of a more science and technology-focused consideration by the Science, Technology and Innovation Advisory Council (STIAC) culminating in its 1995 Report – Making Knowledge Work For Us – and the Government's deliberations and consideration of its recommendations. I would like to take this opportunity to pay special tribute to Mr. Dan Tierney and the members of STIAC for their contribution to this process. I would also like to thank John Travers and the members of the Task Force, for their thorough examination of the TIERNEY recommendations on behalf of the Government.

The STIAC process was consultative, although confined largely to the immediate S&T players: the scientific community, industrialists, and the public sector working in the S&T area.

It was the first totally indigenous, and the most comprehensive ever, review of science policy in Ireland. It achieved a valuable degree of consensus among disparate parties with conflicting views. It was undertaken at a time of increasing commitment of the taxpayers' money to the area and of a growing international recognition of the economic importance of science and technology, evidenced by the technological revolution the world is now living through.

S&T in the Modern Context

Science and technology have become central to all our lives, in some ways obvious and in others more surreptitious. One of the major themes of the TIERNEY Report is the need for greater awareness and raising of the general level of appreciation of S&T today. We need to develop an ability at national level to feel as comfortable discussing issues which have a scientific or technological angle as we do about popular culture, literature and the performing arts. Therefore,

one of the purposes of this White Paper is to provoke a more open discussion, a more wide-ranging debate, taking in the wider public.

Historically and internationally, science policy has not necessarily been about employment and economics. There are examples also of science policy being driven by a belief in science in its own right, that spending on science is its own justification. There are examples also of science policy pursued and driven by the call to arms, whether for defensive or offensive purposes.

In Ireland, for much of the period since the foundation of the State, science and S&T policy were very much ignored and neglected. Formally, this began to change during the 1960s: the National Science Council, later to become the National Board for Science and Technology (NBST), was established. In the late eighties, the NBST was merged with the Institute for Industrial Research and Standards (IIRS) to become EOLAS. However, funding for research, which by definition requires a sustained commitment, was never adequate or secure. The national establishment culture was not supportive.

Since the late eighties, this has begun to change. Much of this has been as a result of the European Union's budget and transfers to Ireland, whether via structural funds or the EU's own research programmes. The view now is one of appreciation, on the surface at least, of the importance of S&T to national development.

This is very much in line with the trend in the European Union as expressed in the Delors White Paper and the recent Green Paper on Innovation. A major debate on the role and purpose of science – how far down the road of relevance and application we should go – is taking place in the Member States as well as at EU level, and will continue over the coming months and years.

For the foreseeable future therefore, S&T funding in Ireland is reasonably secure and we must seize that opportunity to develop the national S&T base and to become convinced, as of right, of the importance of S&T in the development of the nation. One need look no further than the enormous transformations which the Information Society is bringing to all aspects of our daily lives to appreciate the pervasiveness of technology, to imagine the potential impact it will have on the way we work, live and play and, in turn, the consequences for society at large.

S&T in a Societal Context

"Research is elitist by nature. This makes it difficult for citizens and politicians to judge where resources for research should be best placed and where they would be of greatest advantage. However, it is not elitist to determine what Denmark should research into, or rather what we shall live on in order to secure our welfare. Therefore, the Government wants an open dialogue on society's priorities."

"Open Dialogue on Danish Research for the Future"
Danish Ministry of Research and Information Technology
1996 Report to Parliament

In seeking to promote greater public debate on S&T issues, there are three simple but profound questions we can ask of the scientific and technological community which seeks public

funding. They are: What does your project do for jobs? What does it do for society? And what are its implications for the environment?

Increasingly, governments are asking these questions of their research and scientific community and, indeed, of other recipients of public funding.

These questions imply a fundamental shift in approach: away from looking on public funding as investment in inputs (e.g. salaries, equipment, bricks and mortar) and towards seeing Exchequer funding as the purchase of outputs (e.g. jobs, social improvement and environmental quality).

At the heart of this shift is a move towards a 'contractarian' philosophy and practice. As a society we have certain intrinsic objectives (e.g. more jobs, better opportunities, the right to make the most of oneself, a clean environment) and we pursue instrumental goals to achieve them (an educational system and economic and social environment that enables us to fulfil our potential). As a society we also have a 'contract' with the State, whereby Government contracts to 'purchase' necessary instrumental outputs from providers such as the Universities and State Agencies, transparently and economically.

This contractarian framework enables the Government to evaluate proposals from the point of view of effect, relevance and value for money in the context of limited and competing demands for resources (i.e. the taxpayer's earned income) and the accountability of Government to the voter.

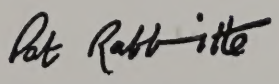
The White Paper

The approach taken in this White Paper is one that locates S&T firmly within the framework of wider industrial, economic and national development policy and, therefore, into the area of jobs and living standards. This White Paper is about the kind of jobs, indeed the kind of society, we want for the future.

We are investing ever-increasing resources in our universities, our colleges and industry. We are producing a large number of highly skilled, creative, enterprising and imaginative young people. We cannot predict where their final destination will be but we must influence the number and quality of opportunities for them to live and work in Ireland.

Barriers to trade are falling and the world is undergoing a second industrial revolution. If Ireland's citizens are to capitalise on these developments, we must plan our policy interventions around companies that can compete, that will grow and create jobs based on research and technological innovation. We must create and grow a climate and culture which put a premium on innovation.

Our aim is to build an innovative economy and society which are founded on a competence in, and a comfort with, modern scientific and technological developments. To do that, we have to invest wisely, always challenging whether that investment is producing the best outcomes or whether it could be channelled more effectively.



Pat Rabbitte TD

Minister for Commerce, Science and Technology

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Overview

This is the first ever White Paper on Science and Technology.

For much of the period since the foundation of the State, Science and Technology (S&T) has been very much ignored and neglected. While this began to change through the '70's and '80's, there is still, despite the pervasive impact of technology in our daily lives, a weak representation of S&T issues in public affairs in Ireland and, more generally, a lack of awareness shown by the public in S&T affairs. A successful policy for S&T and its role in innovation requires a positive public attitude, as well as a sustained commitment by successive Governments over the long-term.

Science, Technology and Innovation (STI) – the High Road to Economic Development

The Irish economy is going through a boom period, with low inflation, low interest rates, the public finances are under control and record levels of jobs are being created. Nevertheless, unemployment remains persistently high and our success in attracting foreign companies to invest in Ireland masks weaknesses in the indigenous sector, comprising mainly small and medium-sized companies.

Barriers to international trade are falling and the world is undergoing a new industrial revolution – the Knowledge Revolution – fuelled by the pace of technological change. If Ireland is to capitalise on these developments we must plan our policy interventions around companies that can compete, that will grow and create jobs based on research and technological innovation. Our aim must be to build an innovative economy and society founded on a competence in, and a comfort with, modern scientific and technological developments.

The TIERNEY Report on Science, Technology and Innovation was the first totally indigenous review of policy in this area. It concluded that "we have assumed that as a small relatively isolated country, we do not need to develop our own expertise and can rely on purchasing innovation from others". This model has worked to a significant degree especially in terms of creating in Ireland a powerful dynamic group of leading overseas companies, using and developing advanced technologies and creating thousands of skilled jobs and exports. But the purchasing of innovation from others also implies that the indigenous sector is losing out in terms of growth foregone, jobs lost, unemployment much higher than it should be, loss of markets, and the worst of all, the loss of talent and the blighting of human potential.

STI policy must therefore work to create an economy characterised by sustainable high employment, high living standards, competition and innovation in an enterprise sector:

- featuring growing use of skilled and qualified staff and rising systematic expenditure on R&D;
- engaged in trading products and services using processes and technologies all of which continuously improve to meet the highest international competition;
- generating and enhancing, as well as absorbing, new technology and new techniques;
- placing particular emphasis on raising the competence of indigenous companies.

The approach taken in this White Paper is one

that locates S&T firmly within the framework of wider industrial, economic and national development and therefore into the area of jobs and living standards. This White Paper is about the kind of jobs – indeed the kind of society – we want for the future.

S&T – The Driving Force in Innovation

Innovation is about how to better make a widget and how to make a better widget. It is about ideas, it is about ways of working, new ways of organising, manufacturing a product, designing or developing an entirely new product or modifying a machine or plant. Innovation is about progress, however defined.

However, innovation is becoming more and more critically dependent on advances in the field of science and technology. We need look no further than the enormous transformation brought about by Information Technology for evidence of the inter-relationship between science, technology and innovation.

Historically, science policy has not always been about employment and economics. There are examples of science policy being "elitist", driven by a belief in science in its own right – that spending on science is its own justification. In modern times, however, and particularly in the fast growth sectors, there are much closer links between product and process innovation, technological advancement and the scientific research upon which they depend.

A critical feature of STI policy therefore is to strongly and overtly link S&T to Innovation and to place it in the context of national development. S&T will be evaluated by its ability to contribute to wider national goals, as a means of achieving them rather than as an end in itself.

Innovation, however, is not a simple, smooth, linear, well behaved process. It is complex and hard to measure. For example, innovation may draw on science but the demands of innovation often, too, force the creation of science. While the interactions of science, technology and innovation are very strong, this should not lead us to accept a common wisdom that technology is merely applied science.

An advanced economy which seeks to achieve its full innovation potential, must develop and create linkages between a number of components as part of a *National System of Innovation*. These components are:

- universities and similar institutions providing basic research and the development of high levels of knowledge and skills;
- business firms, especially those investing in change-generating activities;
- public and private institutions providing general education and vocational training;
- the Government sector, financing and performing a variety of activities that both promote and regulate technical change;
- a venturesome financial sector committed to funding innovation activities.

Taking Action

The TIERNEY Report argues that our failure to develop a national system of innovation is rooted in a weak commitment, even indifference, in national culture to enterprise and innovation, to Science and Technology, to its application and development. TIERNEY concluded that a new vision of innovation is needed embracing the knowledge and skills generated through science

and technology. The Report calls for a programme of planned, sustained and increased investment in research, development and technology application, significant institutional reform and a programme to raise appreciation of the role of science, technology and innovation. It is the aim of this Government to pursue this programme.

In analysing the TIERNEY Report and examining the policy issues fundamental to science, technology and innovation, the Government has already taken action in a number of the more immediately critical areas:

- basic research funding and support for PhDs have been increased;
- administration of third-level research schemes has been improved;
- new funding was provided for post-doctoral research and international collaboration;
- extra funding was provided for schemes to help small firms improve their technological capability, such as Techstart and technology audits;
- taxation measures were introduced to encourage business R&D;
- a scheme to provide training for companies in R&D and innovation management was introduced;
- a programme to encourage networking of firms is being piloted;
- funding is being provided to improve public awareness of S&T.

Now this White Paper sets out the priority needs to be addressed. They are:

- **a planning process for State investment in science and technology to ensure a coherent approach to policy and programmes spread over 12 Departments and over 30 Agencies;**
- **expert and independent advice from a new permanent STI Council;**
- **a substantial increase in business spending on R&D including examination of the tax regime to encourage R&D investment;**
- **a higher profile for technology transfer in industry as an important complement to in-house R&D;**
- **improvement in the capability of firms which currently have little or no technological competence:**
- **increased networking of firms to overcome disadvantages of scale;**
- **address barriers to the availability of seed and venture capital for technology based companies;**
- **recognition of the role of research in the third-level sector and the provision of extra funding as resources permit;**
- **improved organisational structures for the Programmes in Advanced Technology (PATS) which invest substantially in third- level/industry research;**
- **improved public perception of STI and its contribution to national development.**

Planning S&T – Getting our Act Together

This White Paper must be seen in the wider context of reform of the public sector through the Strategic Management Initiative and changes to public expenditure programming in general. It is an attempt in a significant area of public expenditure to impose a basis for good decision

making through rationality, clarity of social and economic purpose and value for money.

No nation can afford to undertake all of the scientific research and technological development it would like. Choices have to be made. Priorities have to be set in line with wider public policy objectives for national development. Funding must be allocated in accordance with these priorities.

The Government agrees that if the Irish economy is to compete effectively in an era of rapid technological change, then the level and quality of S&T investment must be internationally competitive. However, that is a major task that cannot be achieved overnight. The State already invests in the order of £780 million per annum into a broad range of S&T-related activities, including in the education and health areas, but the composition of this investment is only known after the event. The long term objective is to channel this considerable spend into areas where it will be most productive and to engender competition between all the areas which seek funds.

The Government accepts that because of the size, importance and widespread nature of its investment in S&T, organisational structures are required which will provide a long term strategy, facilitate planning of S&T spending and ensure efficiency and value for money. Above all – given our limited resources, our ambition to build a strong system of innovation, and S&T's role in this project – priorities must be established as to where and how S&T funds should be allocated.

The Government has decided to adopt an integrated planning process for prioritising S&T spending, based on the current Science Budget compiled by Forfas and the spending plans of Departments. The process will form an integral part of the annual Estimates and Budget cycles. A Cabinet Committee on STI will direct the process, which will be conducted by an Inter-Departmental Committee. To provide independent expert advice on STI policy and programmes, the Government has decided to establish a new permanent STI Advisory Council.

EU Involvement in Irish S&T

Investment in scientific research and technological development in Ireland has been radically transformed over the last decade by two major external influences sponsored by the European Union– Structural Funds which began in 1989 and the EU's own Research Framework Programmes. The latest round of Structural Funds provides for public R&D expenditure of some £260 million over 1994 to 1999, over 80% of which is EU money. Under the EU's 4th Framework Programme (1994 to 1998) Irish researchers are winning contracts to an annual value of £20 million.

European funding and programmes have, therefore, had a hugely beneficial impact on the Irish science and technology scene by allowing us to develop our own national capability, by leveraging private investment on top of the considerable public monies and by providing opportunities for Irish researchers, to network with organisations abroad.

There is concern that with the major political changes in Europe, a radical shift in the existing Structural Funds system post-1999 is now more in prospect. Equally, in relation to the 5th Framework Programme, due to start in

1998, the preliminary proposals from the Commission have tended to concentrate on a narrow range of activities corresponding to the pressing needs of larger European industry.

If these concerns in relation to the future of the Structural Funds and the EU Framework Programmes come to be realised, resulting in a significant reduction in EU support for S&T in Ireland, it would put pressure on the national exchequer to meet any shortfall.

The Enterprise Sector

Innovation policy is an overarching framework that must link industrial policy, S&T policy, fiscal, educational and commercial law policy with wider economic and social policy. Ireland's failure to become an innovation-driven economy will result in our being squeezed between those, mostly large, countries which develop new technologies themselves, and low cost – low wage economies adapting technology developed elsewhere.

Innovation is ultimately a matter for firms themselves. In Ireland, however, there is still an enormous problem with business spending on research, development and innovation. While spending has been growing at a rate of around 17% per annum since the beginning of the decade, two thirds of Ireland's R&D spending is accounted for by the overseas sector although some three quarters of multinationals do not undertake large scale, systematic R&D in Ireland. More worryingly, however, the vast majority of domestic companies in most sectors of industry undertake no research and development. There is a low level of innovation, reflecting a poor culture and appreciation of science, technology and innovation in the national business community.

The TIERNEY Report identified the key problems to be addressed as:-

- low-level commitment to R&D, innovation and entrepreneurship;
- lack of integration of multinational enterprises into the economy;
- the small size and scale of Irish firms;
- the low technology base of most Irish firms.

Business spending on R&D will continue to be driven by a number of factors including direct State support, fiscal incentives, a more positive perception of technology and innovation in business and a general improvement in the economic and investment climate.

The Department of Enterprise and Employment will monitor the operation of the *Measure 1* R&D grant scheme (which provides for £176 million of private and public investment in R&D over 1994 to 1999) to ensure that new R&D activity is being undertaken and that the number of R&D performers is increasing. The taxation regime will also be examined with a view to encouraging R&D investment. The £60 million seed and venture capital scheme will be monitored to determine if there are specific barriers prohibiting capital investment in technology based firms. Forbairt will introduce a programme of interfirm collaboration aimed at networking activities in groups of firms, based on the very successful Danish model. It will also develop a national technology brokerage activity to strengthen technology transfer into Irish industry.

To develop the low technology base found in most Irish firms, the Government has

provided funding to increase technical graduate placements from 215 to 300 this year. It has also provided increased funding for technology audits and technology brokerage to help companies to understand and absorb new technological developments.

Natural Resource-based Sectors

Within the enterprise sector, Ireland possesses major assets in terms of environmental, agricultural, marine and forestry resources. However, with the exception of agriculture, their potential role in the national economy has not been adequately recognised in the past. There is a need for S&T initiatives to realise the full benefits to the country.

The Minister for the Environment is drawing up a national sustainable development strategy for the environment, including supporting S&T programmes. The Department of Agriculture and Teagasc will examine the level of contributions of the farming community for agricultural research. Food research centres, which receive funding from a number of sources, will have clear Mission Statements, including technology transfer activities. Increased funding for the Marine and Forestry sectors will be examined in the context of the annual Estimates.

Emerging Technologies

State programmes in a number of key technology areas, such as biotechnology and telecommunications, undertake some £20 million of R&D per annum in developing third-level and industry expertise in these areas. The Programmes in Advanced Technology (PATS) have been largely successful in meeting their objectives. However, they require an organisational structure which provides for a common approach to the individual programmes, a competitive funding arrangement to allow new programmes to emerge (or unsuccessful programmes to die), which respects the partnership approach involving the third level, industry and the State, which provides the vision and dynamism for advanced research, and which places emphasis on the development needs of indigenous industry.

The Government has decided that the PATs will be established as a subsidiary company of Forbairt. The company will implement the strategy for the PATs, as laid down by the Minister for Science and Technology on the recommendation of a standing Board established to advise on policy and funding for the PATs.

The Education Sector

Third-Level Research

No subject in the history of public policy debate has generated more heat and less light than the controversy over the role and significance of basic research in the innovation system. Does basic research lead directly to economic benefit for the State in which it is carried out?

It is difficult for any country, particularly a small country, to justify significant investment in basic science across a wide range of disciplines in terms of the contribution it will make to that country's industrial innovation. But there are persuasive arguments for maintaining a basic research capability, including:

- the need to be strong in the basic science of areas of strategic national importance, such as the bio-sciences which are fundamental to health and to the food chain;

- maintaining internationally recognised standards in third-level education;
- ensuring that Irish colleges are attractive to the best Irish undergraduates and post-graduate students and retaining high quality people in Ireland;
- the creation of a pool of skilled researchers and the strengthening of our capacity to participate in international research as an essential basis for industrial and economic development.

Thus, in terms of building a strong national system of innovation, the value of curiosity and the stock of human capital are particularly important. The basic research system is part, literally, of a world wide web of researchers through which Ireland can participate in knowledge generation and acquisition. Basic research funding cannot, therefore, be ignored by STI policy. But in the context of limited resources and the need to build strong links between the third level and the economy, the basic research system must reflect the pressures of prioritisation and relevance.

TIERNEY pointed out that Ireland lacks the Research Council system for funding basic research found in other countries and that this gap has been only partly filled by the Basic Research Grants scheme operated by the Department of Enterprise and Employment. This scheme has increased funding for basic research from £1 million in 1994 to £2 million in 1996. Strategic research funding increased from £0.5 million to £1.2 million in the same period. Health research funding increased from £2.3 million in 1995 to £2.74 million in 1996. The Government accepts that funding for basic and strategic research should be increased as resources permit. It should be allocated according to the excellence of the research, relevance to national economic development, prioritisation of research and performance measurement.

Research at doctoral and post-doctoral level is vital to national development. There are currently a number of support schemes and funding mechanisms which need to be rationalised, and gaps in the numbers and disciplines need to be identified and tackled. To provide research and teaching to the necessary international standard requires access to modern equipment and interaction between the Irish science base and overseas resources. The Department of Enterprise and Employment has doubled the annual PhD research scholarship grant to £2,000 and has launched a scheme for post-doctoral research at a rate of £20,000 per annum for two years. The Department of Education has also introduced a post-doctoral research scheme. The Department of Enterprise and Employment has allocated £200,000 in 1996 for new international research collaboration projects. The Government has asked the Department of Education and the Department of Enterprise and Employment to prepare proposals for the future funding of research equipment.

The TIERNEY Report stressed the importance of improving linkages between enterprise and third-level colleges and the need for the colleges to devote adequate resources to technology transfer activities. Because of their regional dimension, the RTCs have a particularly important role in this regard. To clarify their approach to research, and particularly college/industry collaboration, each third-level college will publish a

Research Charter. Forbairt will consult the RTCs and universities as appropriate in the preparation of regional development plans.

S&T at Primary and Second Level

If we are to develop a more positive culture towards science, research, technology and innovation in Irish society, one of the most important determinants will be the primary and second-level education system. In that context, for example, Information Technology has to be seen as more than a subject on the curriculum. If it is to be ingrained in the minds of young people, it has to be fully utilised as a whole new means of teaching and learning.

The Government endorses the efforts of the National Council for Curriculum and Assessment towards improved teaching of science and technology and there will continue to be improvement in this aspect of the curriculum. There are strong arguments for making technology and enterprise mainstream – even mandatory - subjects, especially at second level. The Government accepts that there are considerable resource implications involved, including materials, equipment, experimental facilities and teacher training. Such resources must be available on an equitable basis throughout all schools, rather than allow a two-tier approach to the education of S&T to develop.

Training and Skills

We pride ourselves also in having a highly educated workforce. The current economic reality, however, is that product life cycles are now much shorter and process technologies are changing more rapidly. The skills with which workers started their working lives are now unlikely to see them through to the end of their careers.

Particularly in the S&T field, with the large and growing numbers being routed through the third-level system and the increasing intensity of the points race, there is a need to ensure that course availability and content is linked to the needs of the economy and the likely sources of employment.

The Department of Enterprise and Employment will produce a White Paper on Human Resource Development in the near future, which will include the need for greater emphasis on skill development and retraining for the employed and on the importance of training for innovation across the full range of firms' activities.

On the question of gender balance in S&T subjects, the State *and* industry lose out if female S&T graduates are not given equal opportunity to use their talents in the business sector. The Departments of Education and Equality and Law Reform will support initiatives to give effect to the strong commitment to equality set out in the White Paper on Education.

Raising the Debate

All the decisions in relation to specific programmes or issues will have a lesser impact unless there is a generally improved public perception of science and technology.

We need to develop an ability at national level to feel as comfortable discussing issues which have a scientific or technological angle, as we do about popular culture, literature and the performing arts. Therefore, one of the purposes

of this White Paper is to provoke a more open discussion, a more wide ranging debate, taking in the broad public. The White Paper represents but the latest step in what is intended as a continuous process of assessment in a crucially important area of public policy.

Apart from its intrinsic merits, science and technology is also increasingly bound up with huge moral and political – philosophical issues, for example in the biological sciences and the development of the Information Society.

The Information Society heralds a new revolution, equal in scale, intensity, effect and implications to the industrial revolution which spread throughout Europe and the New World into the nineteenth century.

Where this transformation will lead is not yet clear. In a sense, there will be no outcome as such, there is simply a continuous process. But there are already visible enormous implications for all aspects of life, in business and trade, work and employment, in education, health and leisure. Many traditional jobs are disappearing as new markets, new types of jobs and ways of working are being created. Long-established industries and ways of life are disappearing. Methods of communication, independent of time, place or defined structure, are emerging. The world is being reshaped on a gigantic scale.

The Government has decided to develop a national information society strategy to plan for Ireland's future in the information age. The plan of action will address aspects of life affected by the new technologies, prioritise actions to be taken and determine how niche areas can be developed. The Minister for Enterprise and Employment has established a steering committee to develop the national information strategy.

But despite the significance of such issues, there is still a general lack of awareness shown by the public in S&T issues. The TIERNEY Report recommended that our aim must be to bring about a significant cultural shift in attitudes and to bring about better communication, interaction and mutual understanding between the scientific community, industry, Government, the media and the public.

The Government has decided to provide financial support for a campaign, to be organised by Forfas, which will promote improved awareness of the importance of science, technology and innovation.

Conclusion

A White Paper normally marks the end of discussion. However, in the S&T arena we need continuous debate both to raise the profile of S&T and to ensure that the country derives maximum benefit from investment in S&T. This White Paper is a platform on which the Government hopes to raise that debate. At the end of the day, however, it is very much the responsibility of the S&T community, whether in academia, industry or elsewhere, to generate and maintain discussion on policy and practical concerns and their impact on the issues of the day. Failure to do so will represent a disservice both to themselves and to the nation.

Part One

A Framework for Science, Technology and Innovation (STI) Policy

"How many people is the earth able to sustain? The question is incomplete as it stands. One must modify the question by asking further: At what level of technology? And modify it still further by asking: At what level of human dignity?"

Isaac Asimov in
Der Spiegel, 1971

FAMOUS IRISH SCIENTISTS

Robert Boyle (1627-1691)

The most influential Irish-born scientist ever was Robert Boyle. He played a key role in the history of science because of his part in establishing the experimental method, on which all modern science is based. At that time, respected thinkers, like Christiaan Huygens and Gottfried Leibniz, were inclined to doubt the value of demonstrating by experiment what they (and all "rational" thinkers) knew to be true by logical reasoning alone. By using carefully devised experiments, Robert established the power of practical science, and knowledge took a giant leap forward.

Nicknamed "The son of the Earl of Cork and the father of Chemistry", Robert was born in Lismore, Co. Waterford, the youngest of fourteen children. After a spell at Eton College, and a grand tour of the Continent lasting six years, Robert began to take an interest in medicine and science. He managed (just) to avoid marriage, and so was able to devote himself entirely to his studies. He carried out important work on the air pump, which he developed, and which allowed him to investigate the nature and properties of the vacuum. For example, he demonstrated that sound could not be heard in a vacuum, that a candle was extinguished, and that an unfortunate cat died.

He was a founder of the Royal Society in London in 1660, and the next year he published the most famous of his many books *The Sceptical Chymist*. In this, he questioned the early belief that materials were made up of four elements – earth, air, fire, and water, instead anticipating modern atomic theory. He introduced many analytical tests, including the use of vegetable dyes as acid-base indicators, and flame tests to detect metals.

To-day's students are reminded of Robert's work when they learn "Boyle's Law", which states that, at constant temperature, the volume of a gas is inversely proportional to the pressure applied to it ($V \times p$ = constant).

The Policy Formation Process

"September 30, 1659. I, poor miserable Robinson Crusoe, being shipwrecked during a dreadful storm, in the offing, came on shore on this dismal unfortunate island, which I call the Island of Despair, all the rest of the ship's company being drowned, and myself almost dead."

Robinson Crusoe
by Daniel Defoe

Introduction

The story of Robinson Crusoe intrigues economists. In the teaching of elementary economics, the story of the single individual, stranded on a desert island, is used as a dramatic device to strip down life to its alleged bare essentials – economic decision-making.

In Robinson Crusoe economists see intelligent, civilised, rational man thrown into a simple state of nature, depending on nothing but his skill and intelligence and subjected to nothing but the scarcity of resources clashing with the limitlessness of desires, and the resultant operation of the calculus of choice, the operation of the iron laws of economics.

The formation of public policy, including public spending decisions, is also represented by economics as something equally rational, logical, systematic; as much driven by prudential considerations such as value for money, coping with scarcity, assessing competing demands, opportunity cost and so on. The formulators of public policy, politicians and public servants alike, are, in the economist's mind, political and public entrepreneurs, engaged always, as private entrepreneurs and individual consumers are said to be, in pure and unencumbered rational calculation. The economists view is that politicians and public servants going about their work are, at heart and in essence, no different from Defoe's mariner of York.

This is an idealisation. The truth is that it is all rather more complex and muddy. The real life of government – whether in S&T or any other public policy area – is not a Robinson Crusoe simple world. Government is complicated by culture and history, by conflicts and coalitions of one sort or another, by competing ideologies, economic rent-seeking, and by conflicts within the civil society. In the public policy arena, policies and programmes also take on a life of their own, open to interpretation as to "success".

Public policy theorists argue that the logic of the rational calculus must, in the end, cut through the complicating layers of culture, conflict, compromise and history – as allegedly in private life.

In private life, however, the problem of choice for the consumer and the entrepreneur or manager can always ultimately be reduced to one of individual choice, including the choice of simply foregoing something.

The problem for public policy is a different kind of problem – the problem of collective action. How can we make concepts such as social dividend and gain, cost (to whom?) and benefit (for whom?) apply in an operational way in the world of the provision of public services? How can public provision escape problems such as economic rent-seeking and "provider capture" at the expense of citizens and clients? Public provision is characterised by the absence or failure, to varying degrees, of markets, and ultimately by a concern with something as broad as the expansion of "our freedom to lead the lives we have reason to value"[1].

One way in which we can begin to resolve these difficulties is through the 'contractarian' framework[2]. Political parties offer voters both intrinsic ambitions (ends) and instrumental goals (means), otherwise known as manifestos. Political parties elected to power, which is to say governments, have a contract with civil society. Government and society need means of measur-

ing compliance and performance. A contractarian framework offers this. It is a duality: a contract of promise between voters and party (for example, for security); and a contract of purchase, between government and providers of means (in our example, the police) for certain outputs (in this case, a low crime rate).

A switch towards seeing spending in terms of purchasing outputs as cheaply as possible, which is to say at the lowest possible tax rate, and away from measuring compliance and performance as inputs, while attempting to measure efficiency, however defined, provides a framework within which the dilemmas of collective action and social provision can be resolved.

Much of the reform of public policy formation and public spending processes undertaken in Ireland in recent years represents a comprehensive attempt to impose discipline, order and democratic choice on the process of decision-making within government, but within the confines and subject to the requirements of a civil society organised on the European social model.

For example, the application of global limits by this Government on public spending and borrowing, and its commitment to the Maastricht guidelines, are attempts to impose logic, order and rationality on decision-making in the public domain.

Partnership on the European social model[3] represents an attempt to limit conflict in the economic arena and provide rules for sharing the benefits of growth. The Department of Enterprise and Employment, by the publication of the strategy document *Growing and Sharing our Employment*, provides a framework for the pursuit of the objective of sustainable full employment over time, while the Forfás report, *Shaping our Future*, provides medium to long-term goals and objectives for society and the economy generally.

This White Paper falls within this general framework. It represents, among other things, a further advance in the process of imposing logic and rationality, clarity of social and economic purpose, and value for money rules, evaluation and economy in one area of public activity, science and technology policy. This is appropriate given the scale, complexity and multiplicity of purpose in Exchequer funding and support of science and research.

Science and Technology Policy Formation

Why is there in Ireland, as elsewhere, a large and growing commitment to S&T spending? There is no single answer. Obviously, employment creation is a major factor behind much of the funding and many of the spending programmes, particularly those of the industrial development agencies – IDA Ireland and Forbairt, SFADCo and Údarás na Gaeltachta.

S&T spending has, in recent years, become increasingly closely associated with support for industrial innovation. This White Paper will have considerably more to say on the subject of innovation in Chapter Two.

Industrial innovation requires upgrading of skills, the development and enhancement of the stock of human capital which is clearly an aim of S&T policy. This is an objective that underpins the Exchequer allocations to the development agencies, including in this instance FÁS.

The advancement of knowledge as such, adding to society's stock of knowledge, is another factor, certainly as regards the allocation of taxpayers' money to and through the Department of Education, for example, and indeed a proportion of the spending funded through the Office of Science and Technology.

Are the balances struck between the various areas of spending, and between public funding and private spend, right – even if only roughly so? In other words, how well defined is the decision to Exchequer-fund at all, and how well chosen, monitored and defined are S&T spending and objectives?

In the language of the school report, performance could truthfully be summed up in the phrase, 'Much improved but must do even better'. For example, there is a poor level of advance co-ordination and accounting for the total S&T budget or spend, although there is now in place a form of accounting after the event. Because the prior co-ordination aspect is still underdeveloped, evaluation and choice is weaker and less co-ordinated than it might and should be. We are, also, only beginning to comprehensively monitor and assess private business expenditure on R&D (BERD) and, as a result, how we might economically leverage this spend.

As this White Paper will demonstrate, all of this is recognised and is being acted upon.

The establishment of a Cabinet Committee chaired by the Minister for Commerce, Science and Technology, recommended by TIERNEY, is further evidence of a strong commitment to co-ordination, rationality and prioritisation in science and technology policy.

The switch, currently being implemented, to multi-annual budgeting for public spending generally should further assist prioritisation, evaluation and choice.

Now, in this White Paper, there are set out a series of Government decisions that will address and correct remaining problems and shortcomings and set a clear, positive course for the future.

The Government has recently embarked upon a major reform of procedure, decision-making and policy implementation within the civil service – the Strategic Management Initiative. The reader will find that the Government's decisions in detail on STI policy, contained in Part II of the White Paper, are very much in sympathy with this reform. They represent a practical and pragmatic working through of issues, in a now well-defined area of public policy of significant importance to national development. Chapter Six, in particular, presents a number of reforms at Governmental level, which is to say at political and inter-departmental levels, aimed at improving co-ordination, prioritisation and evaluation, and ultimately performance.

From an overall point of view therefore, this White Paper must be seen in a wider public policy context and the reform of that context through the Strategic Management Initiative. It is an attempt in one, now significant, area of public expenditure, to impose a logic and basis for good decision-making – good government in other words.

THE ROLE OF SCIENCE IN MY DAY TO DAY LIFE

Dr. Gary O'Toole, St. Vincent's Hospital,

Sometimes I try to imagine doing my job 40 years ago, without all the gadgetry and technology available to me today. I work as a Junior Hospital Doctor in St. Vincent's Hospital in Dublin, a busy teaching hospital. And the thought of not being able to avail of CT, MRI or Ultra Sound Scanners is very frightening – to say the least.

In my working day, I simply cannot avoid encountering science and technology. Every morning starts with a 'Ward Round', this involves a discussion on all the previous days results for the patients, which are, of course, printed neatly for the doctors by the now ubiquitous computer. All tests in hospital now are ordered by computer, confirmed on computer and results usually read by computer.

When I order a blood test on a patient, it is collected by the phlebotomist, sent to the laboratory and, in large batches, placed in a machine which, in a matter of minutes, can tell the scientists whether the patient is anaemic, has an infection, is low in cells that fight infection or is dehydrated. Years ago this was done 'one sample at a time' by a scientist looking down a microscope at each sample individually, and usually took about 30 minutes per sample. In St. Vincent's Hospital, if a blood sample is sent in the connecting chute from the Intensive Care Unit to the Laboratory, the nurses and doctors can expect to have a result back in under 5 minutes. Put simply the computer is the greatest aid to medicine since the discovery of penicillin.

But it's not just the computer that has helped medicine. Technology has advanced to such a great degree that some operations that, in the past, necessitated a 15 cm scar, are now done using a tiny fibre-optic camera, through three 1 cm incisions. Patients that had their operation done the old way, used to stay in hospital for about 8-10 days and suffer a lot of pain, but with the newer method they go home after 3 days, thanks to surgery that is virtually pain free.

Other more 'Headline Grabbing' procedures, now being done by doctors, include transplant surgery. St. Vincent's Hospital is the Irish Centre for Liver Transplant Surgery. Other organs now being transplanted include kidneys, in Beaumont Hospital, and hearts, in the Mater Hospital. Every four years thousands of 'transplant' patients meet and compete in the World Transplant Games. People once so close to dying now compete over the 30 km cycle race or the 10 km road race. All truly remarkable achievements and all thanks to the scientific advances and research that taught us how to prevent the body 'rejecting' a transplanted organ.

And it's not just the world of surgery, where I am presently working, that has taken great strides thanks to science. Medicine too has benefited from advanced research techniques. In no field is this more evident than the field of Oncology (Cancer Treatment). Now because of modern medicines, people are being cured of cancer more often. All cures are thanks to our ability to study things as small as a cell under a microscope and observe how it is affected by certain drugs. There are millions of people world-wide alive today because of recent advances in science and technology.

Chapter Two
Part One

Science, Technology and Innovation Policy at the Level of the Firm

inn'ovate vt introduce new things. [Collins pocket dictionary]

"It is a commonplace that innovation, defined as 'the profitable and continuous exploitation of knowledge and techniques in new ways for fresh purposes in advance of the competition', is crucial to competitiveness, and becoming increasingly so. Innovation includes R&D and the use of new technology, but it extends very much wider, covering every sector of manufacturing (not just high-technology ones) and incremental improvements as much as major changes. It does not necessarily involve investment or new technology."

House of Commons Trade and Industry Committee Second Report on Competitiveness of UK Manufacturing Industry.

Introduction

Science and technology policy has come closely to be identified with the field of innovation. S&T has come even to be equated *per se* with innovation and it has all come to be seen by many to depend critically on public spending. These posited strict identities are not accurate. It is all somewhat more complicated, as the extract from the UK House of Commons report quoted at the beginning of this Chapter makes clear.

Innovation is about how better to make a widget and how to make a better widget. It is about novelty. It is about ideas. It is about new ways of working, new ways of organising and doing things, perhaps manufacturing a product, designing or developing an entirely new product or a new service, or operating or modifying a machine or plant. Innovation is about progress, however defined.

Innovation is the opposite of conformity. It is to break with the *status quo*, the established way of doing things. It requires skill and knowledge but also involves risk, being entrepreneurial, adventurous and putting a premium on curiosity, creativity and inquiry. It is to a degree also about play, "tinkering". And it is about an impulse for improvement and in business, a competitive urge and making money – the pursuit of profit and winning.

A spirit and culture of innovation is always to be valued. In the world of business it is a critical ingredient in securing competitiveness and self-sustaining growth. More generally, the innovative spirit and impulse enriches cultural life and the society. Finally, it is as necessary an ingredient in public administration as it is in the business of commerce and the life of the arts and sciences.

Science, Technology and their Role in Innovation

This is not a White Paper on innovation policy. It is a document on science and technology policy. However, the view adopted in this White Paper is one that locates S&T policy as a subset of innovation policy. This is why, in this White Paper, we talk of STI – science, technology and their role in innovation policy. In turn, innovation policy is a most critical dimension to Irish industrial policy. This will also be a central theme of an Enterprise Strategy paper which will be published by the Minister for Enterprise and Employment in the coming months. In Ireland, industrial policy must concern itself critically with breeding a strong national culture of innovation.

The word *innovation* can be used both in a generic way, and also with some precision. We can talk legitimately in a very general way of "a spirit of innovation", or we can talk much more precisely of "an innovation". An innovation in this latter sense may typically have a technological base. It may, in other words, have its origin in the advance of technology, which is to say "society's pool of knowledge regarding the industrial arts", to quote the definition of a noted economist in this field, Edwin Mansfield.

However, an innovation may equally arise out of a change in technique. Mansfield goes on to observe that "whereas a technological change is an advance in knowledge, a change in technique is an alteration in the character of the equipment, products and organisation which are actually being used."

Which type of act of innovation is the more socially and economically desirable? Can we say that innovation based on technological

advance is superior to an innovation arising out of a change of technique?

An innovation based on a technological advance is certainly of a higher order than a change of technique. Both are to be valued and encouraged. Most critically, an accretion of incremental changes in technique can lead to technological advance, and even to patentable inventions [4].

Innovation and innovation systems are about learning – learning by doing, by using and by interacting. A culture of continuous learning and improvement is, centrally, what we are intent on achieving.

Taking a long view we have to say that it is critically more important to have a strong culture of innovation than to try to hot-house grow inventions. A national culture that is characterised by, among other things, the impulse to innovate, to depart from the *status quo*, to 'tinker' and to take risks is likely, other things being equal, to show a capacity over time for invention also.

A corporate sector that is driven by the competitive urge, in which any individual company constantly fights to depart from the *status quo*, to be first, better and smarter than the rest, is also likely to be characterised by high levels of innovation, a commitment to research and development, to design, to engineering, to training, to the enhancement of skills in the workforce, to continuous improvement and engagement in patenting. All of this we take as indicative of the impulse to innovate.

STI policy in Ireland must contribute to breeding a strong innovation culture in the national business community through encouraging and enhancing innovation in the appliance of science and technology in our industry and commerce.

STI policy seeks to achieve the constant engagement of the business community in the process of technological change and changes of technique, in order to increase employment, enhance productivity, competitiveness, and ultimately profitability, growth and the living standards of all.

The Situation in Ireland

In Ireland, the impulse to innovate is not strong. The TIERNEY Report and other studies are clear on this. TIERNEY, for example, comments that "we have up to now adopted a passive approach", that technological change "has come about, for the most part, through our attracting foreign companies or importing technology in the form of finished products". The Report concludes that "We have assumed that, as a small and relatively isolated country, we do not need to develop our own expertise and can rely on purchasing innovation from others." This model has worked to a significant degree, especially in terms of creating in Ireland a powerful, dynamic group of leading overseas companies using and developing advanced technologies, creating thousands of skilled jobs and exports. But the purchasing of innovation from others also implies that the indigenous sector loses out in terms of growth foregone, jobs lost, unemployment much higher than it should be, loss of markets, domestic and export, and worst of all, the loss of talent and the blighting of human potential.

A recent Forfás audit of 1995 business expenditure on research and development (BERD) tells a mixed story. On the one hand, BERD was much higher than it was, say, five years earlier. It was growing rapidly. On the face of it this is good news.

However, quantum and trend at the aggregate level are not everything. By international standards, BERD in Ireland is still lower as a percentage of national output than in relevant other economies. While BERD roughly doubled its share of national output in the five years to 1995, to reach 1 per cent of GDP it is still below the OECD and EU averages. However, it is not now markedly different from the rate found in some other small economies such as Denmark and Norway. R&D is, in effect, a capital input, a point acknowledged in all studies of R&D impact. What matters with R&D spend is the stock of spending over time and we need to have a substantially higher spend if we are to "catch up" with our competitors.

This overall picture masks certain disturbing features. R&D performance is confined to a very small proportion of companies. Forfás estimates that there were fewer than a thousand companies in Ireland engaged at all in systematic R&D in 1995 and no more than 300 companies spending more than £100,000 a year on the activity. There were less than 100 companies spending £0.5m a year on R&D and this small group accounted for 75 per cent of all BERD.

Most R&D activity was accounted for by overseas companies and the gap between overseas and indigenous companies widened considerably between 1988 and 1995. The average annual growth rate (allowing for inflation) in BERD among foreign-owned companies is considerably in excess of the growth rate among indigenous companies – 21 per cent per annum compared to just 13 per cent. There are, nonetheless, some indications of an increased effort, in more recent years, by indigenous companies.

The sectoral profile for BERD is dominated by electronics (including software), engineering, pharmaceuticals and chemicals. The level of BERD in the food sector, the heart of the indigenous industrial base, is, disappointingly, considerably less than the national average and is growing at no more than the national average.

In short, there is still an enormous problem with BERD in Ireland. It is largely undertaken by the overseas sector although most multinationals do not undertake large-scale, systematic R&D in Ireland. More worryingly, however, the vast majority of domestic companies in most sectors of industry undertake no research and development spending. The low level of innovation reflects a poor culture and appreciation of science, technology and innovation in the national business community.

STI policy in Ireland must work to create an economy characterised by sustainable full employment, high living standards, competition and innovation, indicated by an enterprise sector:

- **featuring growing use of skilled and qualified staff, benchmarking against best practice, and rising systematic expenditure on R&D;**
- **engaged in trading products and services and using processes and technologies, all**

of which constantly and continuously improve;

- **generating and enhancing, as well as absorbing, new technology and propagating new techniques.**

This economy will also be characterised by companies, managements and workforces consumed by the ambition to develop new technologies, techniques and products from within themselves; and financial and public sectors fully supportive of an innovation culture.

Addressing the Deficiencies

But how does the State, to the extent that it must or can, pursue this ambition? There are perhaps eight high-level instrumental objectives:

- the purchasing of improvements in the technological and innovation capacities of indigenous companies through a portfolio of direct support measures such as Techstart, technology acquisition and technology audit;
- the purchasing of relevant and needed additions to the general pool of scientific and technical knowledge and know-how from providers of high-level research such as the Programmes in Advanced Technology;
- the acquisition by Ireland, through IDA Ireland, of facilities and businesses owned by leading overseas companies in high technology areas; their links with the indigenous economy; and the diffusion out of these companies of best practice and techniques;
- the purchasing of enhancements of the stock of human capital from education and training providers, including schools, colleges, third-level institutions and research bodies and State agencies;
- the cultivation of a culture of innovation through an approach that makes innovation a common thread linking together a range of policy areas – for example, fiscal, commercial law, education policy;
- the creation of a venturesome financial sector;
- the maintenance of high growth;
- the encouragement of competition.

All of this is to be pursued within the confines of dealing effectively with other competing demands and the pursuit of financial discipline. STI policy comes into play only in respect of a subset of these instrumental goals – technology transfer, skills enhancement, the stimulation of business sector research and development, the purchase of additions to the stock of knowledge from the basic research community – being the main ones.

Technology Transfer

Technology transfer is strictly speaking "the transfer of knowledge about techniques". It does not necessarily, and of itself, represent an addition to a society's pool of knowledge although it can lead to that.

STI policy support for transfer of technology operates through a number of mechanisms, for example promotion of and assistance to companies to enter into straightforward transfer (or buying in) of technology through entering into agreements with other companies (foreign or domestic) that possess higher level knowledge about techniques and technologies. The principal attraction of this kind of arrangement is that it can be a quicker and cheaper route in the short term to acquiring competence, than developing

and growing competence internally (through the organic route). However, taking the long view, we must see to it that technology transfer spurs the development of internal competency over time.

Human Capital

Companies can also achieve technological competence through a second route, through the hiring of skilled people – the purchasing, in effect, of human capital. Companies, particularly smaller firms, can usefully be assisted and encouraged to take on skilled, trained and qualified staff. Schemes such as Techstart are a case in point.

Taking the long-term view and from the policy standpoint of wishing to see the acquisition and growth of internal competencies, the enhancement of the technical skills and qualifications of in-company workforces is to be preferred.

That is not to suggest, however, that the technology transfer route versus the human capital approach is a simple case of "either/or". The State's 'contract' with companies in receipt of funding under STI programmes should be seen as involving those companies making a contractual commitment in effect, to enhancing their innovation and technological capacities through investing in their human resources and their technology base. There are readily measurable indicators of output here: numbers of certificate, diploma and degree holders employed; engagement in further training and apprenticeship; level and incidence of intellectual property creation; expenditure on innovation.

Multinationals and Local Industry

The very location of overseas industry in Ireland is itself an act of technology transfer. In effect, Ireland negotiates contracts with multinational companies, whereby they agree to locate facilities and functions in Ireland.

In a sense, a multinational functions as a portfolio manager, distributing technologies, management and business functions, its development and production on a global canvas, to maximise shareholder return. Our objective is to see overseas companies more fully integrated into the domestic economy. This is an aim of industrial policy, S&T policy and wider innovation policy.

The rationale for this ambition is twofold. It is good in its own right, and it is a route to more intensive linkages between the overseas and the domestic economy. However, a key question in this respect, is the capacity of indigenous companies to link into and meet the requirements of overseas companies. Links between the overseas and the indigenous sector could be stronger than they are, although they have developed in recent years. However, a number of points need to be made.

The amount of R&D activity now undertaken in Ireland by MNC's is, in the aggregate, in both relative and absolute terms, considerable as the most recent Forfás R&D survey shows. Overseas companies' BERD is the key driver in the recent rapid acceleration of corporate R&D activity in Ireland, although the overseas companies that undertake BERD here are still a minority.

However, part of the problem must lie with indigenous industry. Again, we are back to the recurring theme, strongly expressed in the report of TIERNEY and other studies over the

years: that of the general weakness of the indigenous business community, the National Innovation System and culture. The exception to this general comment is the small group of high growth, high technology start-up companies created by a new generation of entrepreneurs. This new breed is usually highly trained and educated but, critically, has attitudes formed free of the protective formative experience that is ingrained in the minds of managements of older, bigger companies, engaged in traditional industries, based on old technologies and invariably, dependent on the home or British markets. Many of these new entrepreneurs also are the products of the multinational experience. It was through contact with, or employment in, the Irish operations of overseas companies that they got their experience and their business ideas.

A primary focus, in relation to the further integration of the overseas companies into the economy, must initially be the enhancement of the innovative, technological and production capacities and competencies of an increasing number of indigenous companies, large and small, across the range of sectors and industries.

In terms of our outputs approach, the State is in the business of 'purchasing' the enhancement of technological and innovation capacities and competencies of Irish companies. In the case of overseas companies, achieving this objective should create a fertile soil in which that sector can set down stronger roots and further enhance the contribution it is making to national development. In achieving the objective for the indigenous sector, overseas companies have an important role to play – through, for example, demonstration, diffusion and innovation effects, the imposition of high standards on local sub-suppliers, creating a competitive culture and so on.

There is an added reason for strong focus on strengthening the technological and innovation capacities of indigenous companies. This is the fact that there is now a noticeable trend among multinational companies to seek local partners, joint enterprises and alliances, when making investment decisions. The greenfield development is no longer the only option. Therefore, if Ireland is to continue to successfully attract mobile international investment, it must have a population of dynamic indigenous companies, prospective partners for technologically advanced companies from abroad.

In all of this regard, an inputs/investment approach in general and the setting of global targets for BERD are not particularly meaningful. On BERD, as the Forfás 1993 Report on R&D in the Business Sector points out, "it is possible that such (macro) targets could be met without raising the R&D commitment of the vast majority of firms or even whole sectors of the economy." Therefore, as Forfás suggests, targets for increasing the rate of BERD in indigenous firms, for example, should be set at the micro level.

All of this suggests that those STI policy initiatives, that form part of the policy portfolio aimed directly at the business sector, should:

- **very much focus on raising the competence of indigenous companies;**
- **aim critically to increase the skills base, technological literacy and qualification in the workforce employed in companies;**

- **measure results, including the incidence of BERD, at the disaggregated, micro level rather than in terms of broad, macro-level aggregates.**

In Chapter Seven the reader will find detailed decisions dealing with STI policy vis-a-vis the corporate sector, indigenous and overseas, dealing with the need to increase employment of technologically qualified and literate staff; the need to increase R&D activity in business in Ireland; the encouragement of inter-firm networking and so forth.

Beyond this discussion of the operation of STI policy at company level, there is a second great question for policy. This is the appropriate balance between direct support of business on the one hand and funding basic research on the other. In the following Chapter we address this issue through a discussion of the concept and workings of the National System of Innovation.

FAMOUS IRISH SCIENTISTS

Nicholas Callan (1799-1864)

To-day we take for granted the constant supply of electricity available to us in our homes and workplaces. But we would not have this ready supply were it not for the invention of the induction coil, for it was the forerunner of the transformers which make possible to-day's distribution of electric power. The induction coil was invented in 1836 by an Irish priest, working in St Patrick's College, Maynooth.

Nicholas Callan was born at Darver near Dundalk in Co. Louth. He was a remarkably energetic and brilliant scientist. He built enormous batteries, using cells of his own invention, and he patented a method of preventing rust in iron. But the work for which he is chiefly remembered is in electro-magnetism. When a soft iron rod is placed in the centre of a coil of wire and a current passed through the wire, the iron becomes magnetised. While working on such electro-magnets, he found that, when a current sent by battery through a "primary" coil was interrupted, a high voltage current was produced in an unconnected "secondary" coil. Callan sent a replica of his induction coil to William Sturgeon (1783-1850) in London in 1837, and it was exhibited to members of the Electrical Society to their great amazement.

Callan used his fellow seminarians to check the intensity of his electricity. One of his most famous voltmeters was William Walsh, later to be the famous Archbishop of Dublin. The unfortunate young Walsh was once rendered unconscious by Callan, but fortunately he survived. Callan also arranged tugs-of-war between his electromagnets and his students.

To-day St Patrick's College maintains an impressive collection of old scientific instruments in the College Museum including many used by Callan himself.

Chapter Three
Part One

The System of Innovation in a National and International Context

"Knowledge is an increasingly important input into the present day complex manufacturing production process."

"The challenge for Ireland is now to mobilise productive resources in a much less favourable world economic environment than that of the 1950s and 1960s West European Golden Age."

Lars Mjoset
The Irish Economy in a Comparative Institutional Perspective (NESC. No. 93)

Introduction

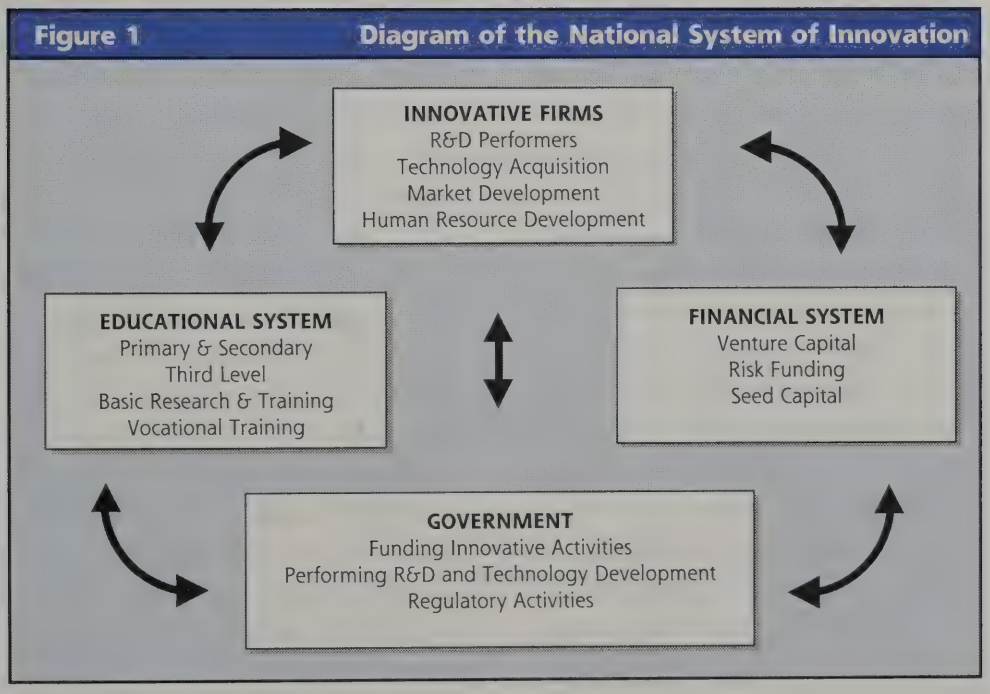
The concept of a National System of Innovation (NSI) is increasingly being used by economic analysts as well as science and technology policy makers. The approach, based on the idea that everything is related to everything else, attempts to capture in a systemic way the underpinnings and forces contributing to the level of innovation (or the lack of it) in the economy.

The concept is treated in some detail in NESC Reports numbers 93 and 96 (The Irish Economy in a Comparative Institutional Perspective and Strategy for Competitiveness, Growth and Employment).

Figure 1 shows the wide range of institutional factors which impact on innovation. These include communication and interaction within and between firms, user-producer relations, the education, training and incentive systems and formal research institutions. It follows that innovation involves all aspects of bringing an innovative idea into the market. Technology is a very important aspect but there are other factors including design and marketing which contribute in this area.

TIERNEY defined the National System of Innovation (NSI) as "the collection of all institutions and mechanisms (public and private) that interact to stimulate and support innovations in products and systems within the national economy". It went on to say that science and technology are the main driving forces of change and that knowledge, and the skills and expertise to apply it, are the new driving forces of modern industries and countries. The key to success in translating knowledge into successful innovation is the effectiveness of the entire system. "It is not just R&D, essential though this is,

Figure 1 Diagram of the National System of Innovation



but the variety of elements and the quality of interactions and linkages that compromise the NSI which are important". (TIERNEY, page 52)

Innovation is rarely smooth or linear or well-behaved. It is complex, variegated and hard to measure.

The generally accepted model of innovation since World War II has been what some authors call the linear model. In this scheme, one does research, research then leads to development, development to production and production to marketing.

In this system, knowledge emanates and flows from the pure scientific font through the domains populated by applied scientists, engineers and technologists. Knowledge is drawn off by these lower order layers to be used, modified and adapted.

However, in the linear model there are no feedbacks from within the ongoing work of development, from sales figures or from individual users. But all of these feedbacks are essential to evaluation of performance, the formulation of next steps, and the assessment of competitive position. Feedbacks are an inherent part of the continuous development and innovation processes.

Another difficulty with the linear model flows from the fact that the central process of innovation is not science but design. A design in some form is essential to initiating technical innovations and redesigns are essential to ultimate success. Science often is dependent on technological products and processes for its advances.

Innovation draws on science but the demands of innovation often force the creation of science. The interactions of science and technology in the modern world are very strong. But this should not lead us to accept the common wisdom that 'technology is merely applied science.'

A successful National System of Innovation has two fundamental requirements:

- strong and vigorous components of the system;
- extensive and productive interaction between the components.

For an advanced economy the key components of the National System of Innovation are:

- universities and similar institutions, providing basic research and the development of high level knowledge and skills;
- business firms, especially those investing in change-generating activities;
- public and private institutions, providing general education and vocational training;
- governments, financing and performing a variety of activities that both promote and regulate technical change;
- a venturesome financial sector committed to funding innovation activities.

Within the Irish system of innovation there are a number of important issues and influences which deserve particular analysis from a policy perspective.

The Role of Basic Research

No subject in the history of public policy debate has generated more heat and less light than the controversy over the role and significance of basic research in the innovation system. Things were a lot clearer in the seventeenth century when Francis Bacon argued that theoretical science is the only real science, the basis of all knowledge and advance, and that such work must be funded by the State as private sources would have neither sufficient resources nor interest. By the late twen-

tieth century, however, the complexities of history had considerably muddied the waters.

The basic research system is not confined by state boundaries. Nor is it the property of any one state. Basic research is like literature. It is carried out in a global context, with researchers from all over the world deriving inspiration and ideas from each other and competing for the next Nobel prize. The university system is responsible for almost all of the basic research carried out in Ireland; however, it represents only one third of the total research carried out in colleges. Over the past decade, college research activity has become more oriented towards applied and developmental research, as academic researchers generate funding through external contracts.

But does basic research lead directly to economic benefit for the State in which it is carried out? Wealth comes from the application of science. The post-war performance of Japan owed nothing to its own performance of basic research and everything to its ability to find out, understand and appropriate what other countries had discovered through their own research efforts. In particular, Japan targeted the United States, by then the world leader in state-funded basic science as a result of the most influential of all science policy documents: *Science – the Endless Frontier*, by Vannevar Bush; Chief Scientific Advisor to the US Government at that time. Others have argued that the continued strength of the US economy over the last fifty years is a reflection of its leadership in basic science and of the strength of its universities and research infrastructures.

The importance assigned to pure science in Europe over the decades has still not stopped the "European paradox", as it is called in the recent Commission Green Paper on Innovation, from emerging as a singular problem for the EU. The Commission's paper posits a paradox: Europe is strong on science but weak on innovation – turning science into products and profits.

This has also been the traditional criticism of the UK, where examples abound of scientific discoveries in British universities being commercialised in other countries. Cultural and social attitudes to scientists and engineers (as opposed to lawyers and accountants) have sometimes been blamed for this phenomenon. Problems in other parts of Europe are of relatively recent origins, as the innovative performance of post-war Germany demonstrates. Switzerland is also an example of an economy which has maintained a strong manufacturing sector together with high wage levels, combined with outstanding universities and a strong commitment to high-quality research.

It is difficult for any country, particularly a small country, to justify significant investment in basic science across a wide range of disciplines, in terms of the contribution it will make to that country's industrial innovation.

But there are persuasive arguments for maintaining basic research capability in the colleges. These include:

- the need to be strong in the basic science of areas of strategic national importance, such as the bio-sciences which are fundamental to health and to the food chain;
- maintaining internationally recognised standards in university education;
- ensuring that Irish colleges are attractive to the best Irish undergraduate and post–graduate students, retaining 'high quality' people in Ireland;

- creation of a pool of skilled researchers, as an essential basis for industrial and economic development;
- the strengthening of our capacity to participate in international contracts and to acquire new knowledge through international co-operation.

From this point of view, the third-level education system, through its basic research activities, delivers three types of output: knowledge, curiosity or intellectual vigour, and people with skills, qualifications and experience who populate or pass through the research system.

In terms of building a strong national system of innovation, the value of curiosity and the stock of human capital (people) produced or trained, are particularly important, although these are also outputs of the rest of the educational system. However, the basic research system has an international dimension to it: it is part, literally, of a world-wide web of researchers through which Ireland can participate in knowledge-generation and also in the acquisition for use of other people's knowledge. It is also capable, in a way in which the undergraduate system is not, of building close, contractual knowledge-generating links with businesses.

In this regard, due to the speed of change, and with the advances in communications and high speed computing, there is a process afoot in the industrial economy globally whereby basic research is becoming directly more economically important than it has been for decades[5]. Technological change, and even the inventive leap, are much more important than they have been since the late nineteenth century. Theoretical research in quantum mechanics in the 1920s and 1930s was the foundation for the modern microelectronics industry which developed forty or fifty years later. But now, advances in solid state physics can be taken up almost immediately through the commercial applications of high-frequency lasers in ever more powerful CDs.

By all means, every effort must be made to direct public funds towards building very strong links between the third-level system and industry, with the basic research system reflecting the pressures of necessity and use.

Undoubtedly the basic research system is a major component of the National System of Innovation, for all of the reasons noted above. The smooth functioning of this system is important for a country's success. One of the key determinants of the differential pace of innovation among countries, is the quality of a country's scientific base, the presence of research institutions and, above all, its education. A country with a scientific élite, but with a workforce poorly trained in the appliciation of S&T, may be an innovator, but it will find it hard to ensure that new ideas are effectively used at home. The ability of a workforce to make the best use of new technologies may be a country's best competitive advantage.

The arguments for supporting basic research are therefore complex. The complaints of academics are sometimes self-serving. The most compelling rationale is probably the need to retain in the country the intellectual élite, who will go abroad if challenging opportunities are not available at home.

In an increasingly technological age, it would be wise to heed the results of a US survey of 650 industrial research executives, spread

across 130 industries, which found that " industrial scientists and engineers almost always need training in the basic scientific principles and research techniques of their field, and providing this training is a central function of universities. Current academic research in a field, however, may or may not be relevant to technical advance in industry, even if academic training is important."

Compared with many of our competitors Ireland has a relatively high proportion of the relevant age cohort in second-level education but there is a particularly low proportion in the technical/vocational area. At third level in Ireland, the balance of technology oriented degrees is biased, again compared to competitor countries, towards natural science rather than engineering. Further, a very low proportion of female students study engineering. Until we rectify these trends our innovative performance will be less than desirable.

The research capability in the third-level system is the largest store of technological human resource available to provide ideas for and to solve problems in innovation, in developing new products and processes and in their widespread application. The third-level research community seeks to collaborate with enterprises and researchers abroad, and this tendency is actively promoted by STI policy.

What this suggests is that funding of basic research cannot today be ignored by STI policy. However, it also suggests an approach to Exchequer funding that is very much driven by the stamp of "national characteristics" (a weak National System of Innovation, a poor culture of innovation and low appreciation of technology and innovation in the indigenous business community). From this point of view, STI policy concentrates on directing expenditures and effort towards building very strong links between the third level system and industry, with the basic research system reflecting the pressures of necessity and use – one of the objectives of, for example, the Programmes in Advanced Technology (the PATs).

Innovation in Enterprise

Empirical research across a range of countries has shown that it is firms which are the prime movers in the innovation process, with research institutions (including the third-level colleges) and government policy playing important influential roles.

Innovative firms are highly competent in product design, production, management, marketing and inter-firm links. Achieving these attributes requires investment, but a high capacity to innovate need not necessarily require large spending on formal R&D. In addition, these firms generally operate in highly competitive environments and cater to demanding domestic markets. The result is that innovation is a cumulative activity, stimulated by a number of identifiable institu-tional features and linkages which seem not to have developed in Ireland. Thus, despite the availability of new technologies, the failure of institutional change to proceed in an optimal manner in the face of technological change, means that productivity and output in many sectors of the economy has not grown near its potential. Overcoming this disjuncture requires the strengthening of the Irish National

System of Innovation, thus improving the rate of growth of output and job creation.

STI policy on its own will not create a culture of innovation although the purpose of contributing to the building of such a culture gives STI policy its rationale. STI policy must be fully supported by, and must itself in turn also support and influence, other policy domains. Innovation policy is an overarching framework or theme that in Ireland, as in the rest of the EU, must link industrial policy proper, S&T policy, fiscal, educational, and commercial law policy (including intellectual property law) and wider economic and social policy.

Failure to implement policies to embark on a virtuous circle of innovation, investment and output growth will result in Ireland being squeezed between those, mostly larger, countries which develop new technologies themselves and low-cost, low-wage, economies which can, in the global trading conditions in which we now live, also tap advanced technologies and capital.

A wide range of institutional factors must be addressed, including linkages within and between firms, user-producer relations, the education and incentive system, consensus building, demand-side factors and issues concerning formal research institutions. This process will also include strategies to improve the quality and motivation of the workforce, strengthening of external trade performance, marketing improvements and a balanced approach to regulation, investment and R&D. In addition, measures to improve the degree of competition within the economy may be helpful.

An innovation triangle can be envisaged. This involves linkages between consumers, producers and researchers to put in place the innovation components absent from the Irish system. These will also involve linkages at both levels of the Irish industrial structure, i.e. between innovations in the foreign-owned sector, and between Irish companies and global development blocks located in Ireland.

Actions and policies to promote technology transfer are an effective means to achieve this. However, special emphasis must be placed on the ability of small and medium-sized Irish companies to avail of, and partake in, the transfer and innovation process. Policy should also concentrate on linkages between the indigenous industrial sector and the natural resources sector, to exploit inherent competitive advantages and opportunities.

Reform is required in the education system and linkages between education and the labour market.

The importance of the public sector in Ireland means that a range of opportunities exist to promote innovation, especially in relation to procurement and to set an example of good practice. Many of these opportunities are not being availed of at present. By instituting a competitive process, the potential obtained through coherent income and macroeconomic strategies, will become manifest in terms of competitive performance and an enhanced rate of growth of employment. Continuing global integration, the expansion of free trade and Ireland's reliance on what remain footloose industries increase the urgency of the need for these measures.

Ireland will only improve its poor record of converting new ideas into concrete realities

when its institutional structure is conducive to innovation. This requires effective and efficient mechanisms to channel individual and company actions made in their own interest for the public good.

Ireland's National System of Innovation will only function effectively when enterprise sector demand for support from, and interaction with, the other components of the system is operating to the maximum of its potential. Having a large proportion of the manufacturing sector with their innovation capability based outside Ireland, and the non-competitive public sector unwilling to innovate, is a major drawback. For example, innovation is just as applicable and just as necessary for increased productivity and human welfare in the area of social goods and services such as the environment and our education system. However, expenditure on R&D and innovation performance is decidedly weak in this area.

Finally, while firms are central to the national system of innovation, in many sectors only a small part of the technological effort of enterprises is carried out in permanent R&D facilities. R&D is not the only way that technological innovation is performed – design and trial production are others. The evidence in Ireland is that R&D activity is, on average, about one third of such innovation effort in Irish firms.

As well as public sector and individual firm activities, there are other 'external' factors which have, or could have, a major influence on innovation performance.

Belonging to networks where R&D is being carried out, and where technological information including "technology watch" activities are readily available, is important to smaller enterprises. The level of such co-operation among Irish firms is very low. The capacity of the national system of innovation to provide for and service the technological requirements of such firms is increasingly important.

The financial system in Ireland, both in terms of the availability of venture capital and seed financing for new firms, is not conducive to innovation. Fund providers are unaware, or unable to assess, the opportunities in high technology businesses and are reluctant to provide finance based on intellectual property collateral instead of fixed assets.

More fiscal support is needed to encourage firms to perform R&D and the tax regime is still inimical to risk taking.

Ideally, science and technology would be as integrated into our society as are the arts. The citizens of Ireland should feel comfortable discussing topics with a strong science and technology content and be confident in their decision-making on these issues.

Our economy is becoming ever more knowledge-based and particularly more technology-based. It is essential to our social and economic welfare that a far higher proportion of people appreciate the role of technology in the economy and have knowledge of science and technology, their interactions and applications. Ideally, the long-term goal has to be to integrate science, technology and innovation into our culture, to improve the level of debate and decision-making about technological issues and to have a more innovative economy.

A better public awareness of the role of science and technology in economic development would have the effect of stimulating gov-

ernments to do more to improve the National System of Innovation.

Impact of the European Union on the Irish STI Environment

No system of innovation can exist in isolation from international scientific and technological developments. Public investment in research and technological development in Ireland has been radically transformed over the last decade by two major external influences sponsored by the European Union. These are the Community Support Frameworks (CSF or 'Structural Funds') which began in 1989 and the EU Research Framework Programmes. These initiatives in a sense represent a new dimension to our contractarian framework. They represent a contract with the European Union, whereby, for its part, the Union transfers resources to Ireland as an Objective One (less developed) region as part of the Union's commitment to cohesion and Ireland for its part, uses those resources wisely as part of a programme to bring its level of development at least up to the EU average.

The Industrial Development Programme in the first CSF (1989-1993) contained a Sub-Programme for Science and Technology amounting to more than £142m. This Programme enabled a wide range of public initiatives to be established: examples are the Programmes in Advanced Technology; Technology Centres in the RTCs; technical graduate placements; and support for business sector R&D. The impetus to the system from this injection of funds was continued under the new CSF (1994-1999), where, of the total public R&D expenditure of some £260m, £217m or over 80% is EU money.

The European Union is a remarkable achievement. In a still-limited number of policy areas it truly is a Union. Research is one of these areas – something that is little appreciated by the general public. The European Commission has always considered the development of scientific and technological capacity as important for economic development. For example, the total budget of the present (4th) Framework Programme is more than ECU13bn (£10.5bn).

The commitment to research is most recently borne out in the treatment of R&D in the EU Green Paper on Innovation. The EU has, therefore, been active in its support of Irish R&D proposals. To secure continued support from Europe in the future will require a coherent case for R&D programmes in the discussions for the next round of Structural Funds where, once again, technological development will be seen as a major priority.

The EU Framework Programme has had a very positive effect on the Irish R&D capability. The Framework Programme embraces all of the research activities funded by the European Commission including industrial technologies, agriculture and food, the marine, energy, the environment, health, and the training of researchers.

The objective is, within the cohesion philosophy, to strengthen the scientific base of the economy and encourage industry to become more competitive at international level, while promoting all the research activities required by the Maastricht Treaty.

EU research is also conducted having regard to the principle of subsidiarity. The implication of this is that generally the research is

aimed at a European need rather than the need of an individual Member State. The research, therefore, tends to be carried out by consortia of research teams from different Member States.

The Irish research community has competed very successfully to date in EU programmes, demonstrating their ability to participate and, indeed, lead international consortia. Irish researchers won contracts to the annual value of £15m under the 3rd Framework Programme (1990-1994). This annual figure is up to £20m under the 4th Framework Programme (1994-1998), in which, to date, Ireland has secured 457 contracts involving 164 organisations, to a value of approximately £55m, with almost 30% going to Irish industry.

An important aspect of the EU Framework Programme, is that it enables Irish researchers in industry, third-level colleges and research institutes to network with organisations abroad and to be involved at first hand with technological developments in Europe and elsewhere. The number of linkages in the current programme is estimated at 3,500 over all disciplines. Without such linkages, it would be more difficult for the Irish research community to maintain its standing in the global scientific and technological community and to transfer the benefits of international research to Ireland.

Over the years, there has been a concern to ensure that small and medium-sized enterprises could fully participate and derive benefits from the Framework Programme. As part of its EU Presidency activities, Ireland is taking the lead on further initiatives in this area. A Working Group, chaired by Ireland, has produced a report proposing a series of actions which will enhance opportunities for SME's to participate in the 5th Framework Programme, which commences in 1999.

One aspect of European research is that it should take into account the economic and social disparity which exists between regions of the Union and give preferential treatment to the less-favoured regions as required by the Treaty. Ensuring that this is put into effect in European research (while respecting the criterion of excellence in selection) has always been a challenge for the cohesion countries and may be an even greater challenge in the 5th Framework Programme.

The debate on the 5th Framework Programme has been launched under the Irish Presidency. There is a tendency in the Commission's first strategy paper towards concentration on a narrower range of activities corresponding to the main pressing needs of large European industry; for greater flexibility to be able to respond to most immediate needs (e.g. the BSE crisis); and for the institution of a number of task forces of primary interest to particular clusters of Member States and industry sectors.

The Framework Programme has served Ireland's interests well and we should endeavour to maintain the basic pre-competitive character of these Programmes. Ireland fully subscribes to the need for better prioritisation of research expenditure and for flexibility to be able to respond quickly to emerging trends or problems. While supporting better prioritisation and a focus on better exploitation of knowledge and its conversion into improved competitiveness, products and services, we must also show proper respect for the Maastricht requirements in regard to

cohesion and subsidiarity. All the Member States can make a contribution, according to their national strengths and opportunities, to European-wide competitiveness. We believe the EU research effort should be community-wide and unifying in nature – inclusive, not exclusive.

The EU Framework Programme, while big in absolute terms, represents only 4% of total European public research expenditure. There is, therefore, an even greater challenge, recognised in Maastricht, to secure greater co-ordination of national research priorities in the Member States to produce a more coherent, effective and truly European effort. Ireland supports this and will participate fully in such efforts and will put in place structures to maximise the benefits of such co-ordination.

Every effort has been made in the many EU-assisted research programmes developed in Ireland to concentrate on investments with a practical application and a reasonable expectation of generating support from private sources. There has been a recognition from the start that Structural Funds will not last for ever and that programmes must aim to become increasingly self-sufficient. But such is the long-term nature of many R&D initiatives that full commercial viability is never an option. With the major political changes within Europe in recent years, a radical shift in the existing CSF system post-1999 is now more in prospect. Should this result in a significant reduction in EU support for public funding of science and technology, it would put pressure on the national Exchequer to meet any shortfall.

The Information Society – an Agenda for Discussion

The impact and implications of the rise of information technology, the information economy and the information society are enormous. The following paragraphs set out some discussion of some of the more major themes. They are preliminary and discursive and intended to prompt debate and discussion. They are included because of the premium the information economy puts on strong national systems of innovation.

For most of the fifty years that the technology of the information age has been around it has largely been neutral in terms of its employment effects.

In financial terms, for most of the period, its diffusion, spread and adoption has been characterised by great waste, huge costs and little perceptible gain for the organisations adopting it. Typically these organisations were governmental or large commercial entities such as banks and very big industrial concerns. In the language of economics, information technology has been hugely sub-optimal for most of the fifty years that it has been around.

However, the last decade has seen history reversed. Everything has changed utterly and nothing remains the same.

The seminal change was in the shape of the IT marketplace. The supply side of the market became competitive and competition changed things. Prices fell, innovation flourished, companies were created and grew phenomenally and in some cases died and in others, changed their colours more than once.

This competitive market process has made information technology become all-perva-

sive, hugely more accessible and usable by everyone. In technological terms also, there has been a fundamental change in architecture.

We have gone from centralised to distributed computing and from narrow number-crunching to word processing and communications and beyond that, to incorporating information technology in industrial manufacturing processes and in the provision of services: robotics, control systems, kiosks, ATMs, laser checkouts and so on. And the revolution is still incomplete.

The cumulative effect of all of this amounts to nothing less than a new industrial revolution, equal in scale, intensity, effect and implications to that of the nineteenth century. And, as with the original industrial revolution, the societal impact is profound, potentially in both the negative and positive senses.

Business and Trade Aspects

IT and the information society have magnified and accentuated market forces, the spread and use of the market mechanism and the premium that attaches to possessing a strong system of innovation. These developments, of course, are not all down to IT, although IT and the re-shaping of that industry in the last ten to fifteen years, has been a major driver of these trends. In the same way as steam, steel and science lay at the heart of the first industrial revolution, innovation, the appliance of science and technological progress are at the heart of this, second, industrial revolution.

The information economy will have a dramatic impact on the way business operates. Companies will have to adapt to the advantages in terms of marketing, trading, networking, innovating and co-operating with others to exploit an ever-growing customer base. It will alter the way technology is transferred. The major opportunities for Ireland being created by the information economy include the internationalisation of the services sector. Banking, education, medical, shopping, publishing, logistical, maintenance and many other services will, in the future, increasingly be supplied remotely to international markets via telecommunication links. However, the capability of firms around the world to compete in the Irish market is also a threat.

We cannot undo or reverse the emergence of the information age. To rise to the challenges presented, business will have to act responsibly and strategically and trade unions will be required to exercise leadership and realistic negotiating stances. We cannot run away from these responsibilities or pretend that everything is inevitable.

The new technologies also provide the opportunity to improve the cost effectiveness of public services and to reduce disadvantage especially in rural locations offering a better service to the citizen and support to companies.

Work and Jobs Aspects

Many traditional jobs are disappearing as new types of jobs and ways of working are being created. Long-established industries and ways of life are disappearing and certain lines of demarcation are being eroded. Established skills are being replaced. New skills requirements are emerging. The world is being reshaped on a gigantic scale.

Through it all, looked at from the standpoint of the impact on business and jobs, certain forces and trends are discernible.

The service content of economic activity is growing. This is sometimes misrepresented as growth of the service sector, as a sectoral shift in other words. In fact, service is being built into virtually everything. The world, increasingly, is all about service – which is not the same thing as the outmoded notion of the service sector.

There is increasing emphasis on formal qualification in the labour market. There is even a degree of what is called qualification inflation. The kind of 'informal knowledge' required of a typical manager or worker is also changing. Some level of computer literacy is now virtually essential for many tasks although IT is also becoming simpler. These forces have enormous significance for the future of education and the educational system.

There is a clear trend towards globalisation of the world economy. This, partly, is as a result of the information society. It is partly due to other forces as well. Overall though, the labour market effect is to increase job flexibility and, thus, insecurity.

In the area of business organisation, there is a clear and present trend towards vertical disintegration, the unbundling of companies and activities, accompanied by ever-wider use of markets: sourcing out and in, subcontracting, supply pyramids and the like.

In the information economy, the jobs market is now increasingly characterised by three types of work. First, there are routine production services. These are low grade, repetitive tasks. But we make a serious mistake if we think of these jobs as being confined to old industries. They are also to be found throughout the IT sector. These jobs are declining. They are insecure, low paid and not necessarily unskilled or low-qualification jobs by any means. They are very much subject to global competition.

Secondly, there are in-person service jobs – everything from driving a taxi to serving in a shop or working in a restaurant. In-person service jobs are growing although much of this statistical growth may be related to organisational change – vertical disintegration. They are also largely local jobs, not subject to global competition, but very much dependent on the health of the wider local/national economy.

Finally, there are symbolic-analytic service jobs. What we are describing here are those jobs that involve problem-solving, strategic thinking, high-level management and so on. They embrace entrepreneurial and creative activity as well as the professions. These jobs are increasingly footloose – with the global communications to which IT has given birth they can locate anywhere. These symbolic-analytic tasks, and the functions to which they relate inside any company, are key to securing competitiveness. They are all about the capacity to create and innovate. To create and sustain these jobs requires investment and change in educational infrastructures, an enterprise culture and a society that puts a premium on creativity and curiosity – in essence, a strong national system of innovation.

New methods of working, independent of place, time or definite structure will emerge and in a related way there will be both an opportunity and a necessity to engage in lifelong

learning and education away from the traditional venues of classroom and place of employment.

Societal Aspects

In addition to working and learning conditions, health, leisure and other societal aspects – the way these products are produced, delivered and consumed – are undergoing dramatic upheaval. Where, when and with whom we interact will involve much wider freedom of choice.

However it is also open to generating socially and economically unacceptable and undesirable outcomes, deepening of social cleavages, unequal distribution of access to, and the benefits of, the information society and so on. The Information Society is first about society-people- not information or technology. Above all we must avoid creation of the two-tier information society – those who have preferential education and access to the means and those who are at risk of further marginalisation because they have not.

Government, at national and EU levels, has key decisions to make in areas such as education and training, putting meat on the idea of universal service obligation, and intellectual property law, as well as creating a climate for enterprise, curiosity and competition. The quality and cost-effectiveness of our communications infrastructure needs to be up to date.

Nobody knows what the outcome of it all is going to be. In a sense there will be no outcome as such, there is simply a continuous process. But, we have the power to influence events. We have a duty to do so because it is possible to build a better society for all, and increase employment opportunities, out of what is now happening. The development of the new age cannot be left solely to market forces.

Government Decision

The Government has decided to develop a national information society strategy and plan of action. The strategy will plan for Ireland's future in the information age, identify our aspirations in the information society and the niche opportunities for Ireland in the global information marketplace. The plan of action will address aspects of life affected by the new technologies, prioritise actions to be taken and determine how niche areas can be developed. The Minister for Enterprise and Employment has established a steering committee to develop the strategy and action plan. The committee comprises representatives from a wide range of State and private sector organisations including the Departments of Finance, Transport, Energy & Communications and Enterprise & Employment, Forfás, ESAT Telecom, ICTU and industry. It will be augmented as appropriate and will produce a report in early 1997. The Government will then adopt an action plan addressing the opportunities and challenges of the information age and how to ensure Ireland's full participation.

STI -The White Paper

Part Two

Implementation of Science, Technology and Innovation Policy

"We have assumed that, as a small and relatively isolated country, we do not need to develop our own expertise and can rely on purchasing the innovations of others. This is an approach which other small advanced countries have rejected, realising that every country must build a capacity to create, absorb and apply new technology, whether developed locally or elsewhere. Ireland must adopt a similar ethos if innovation is to prosper."

Making Knowledge Work for Us
Report of the Science, Technology and Innovation Advisory Council
(the TIERNEY Report).

CONFESSIONS OF A TECHNO-FREAK!

Pat Kenny, RTE

Point me at a machine, any machine, and I want to know what's inside, how it works. And if I was let, I'd take it apart, (putting it together again might be another matter!). I just can't help it. People who don't know me might presume it's because I had a technological education. But the fascination was there long before an educated understanding. As a child, everything in the house that whirred or buzzed or crackled was threatened by my curiosity. A constant preoccupation was the construction of a perpetual motion machine, doomed to failure. Attempts to build electric batteries and electric motors perished in confusion of domestic chemicals and inadequate tools. It was fun-my idea of fun anyway.

But I can see how so many people are intimidated by science and technology, and its arcane terminology. Spare a thought for those high-powered executives with expensive PCs on their desks; they look great, pity they don't know how to use them. It's funny, but when it is new, technology either inspires or intimidates – when it has become commonplace we stop seeing the wood of the technology for the trees of the end uses. Consider the wonder, if you can recall it, of the microwave oven or the first tiny Walkman! The truth is that technology, whether it's buried in the automatic washing machine, the hairdryer or the computer, is there to serve us.

Broadcasting, being a twentieth century phenomenon, was born in the age of change. The technology of broadcasting is a continuum of change, and the software of broadcasting – the words, the pictures – have been among the great catalysts of change this century. For example, the fall of the Soviet empire was made inevitable, I believe, by the advent of easily received satellite television. We, as professional broadcasters, have almost a duty to employ and deploy the best technology we can, but to make sure that no matter how sophisticated it is, that the technology itself does not get in the way of the communication.

Today, whether at home or in work, my instinct is always to have the best, the most up-to-date technology I (or RTE) can afford. But I have to admit that I am sentimental about technological artefacts – I still have my old UCD sliderule, even though this wonderful device has been made obsolete by every £10 calculator. And I believe that no man or woman today can claim to have an education unless they have some understanding of basic and applied science.

Chapter Four
Part Two

The TIERNEY Report: "Making Knowledge Work for Us"

"We all have a vision of an Ireland where each of us enjoys a rising standard of living; where we can avail of the best healthcare and education; where value-added jobs mean security for all and where business – small and large – driven by invention, imagination and creativity ensure that we can compete on the world stage. Itis not a pipe-dream. It is an achievable goal. And it all depends on our ability to stimulate growth through knowledge generation, innovation and the application of technology."

Dan Tierney, in
Chairman's Introduction to the
TIERNEY Report

Introduction

Despite our private desires we have not as a society achieved the good life for all to which we aspire, and which Mr Dan Tierney so well describes, in the quote on the title page of this Chapter. Central to this failure is another, that of failing to develop a strong National System of Innovation. In turn, this failure is rooted in a weak commitment, even indifference, in national culture, particularly the culture of the national establishment, to enterprise and innovation, to science and technology, its application and development.

The Report of the Science, Technology and Innovation Advisory Council (STIAC), chaired by Dan Tierney, is a comprehensive review of the complex of issues surrounding science and technology, their roles in innovation and national development. It is the first report of its kind undertaken, using our own expertise, since the foundation of the State. That fact alone says something about the chronic indifference in Ireland towards this subject.

The STIAC process brought together all of the parties directly involved in science and technology and their contribution to economic development – business, college researchers, trade unions, Government Departments, State Agencies and representative bodies. Its conclusions are based on a wide consensus. They are supported by the international evidence that technological innovation, through the application of knowledge and skills, is central in the dynamic and interacting processes of economic growth, wealth creation and high-quality, sustainable employment.

The TIERNEY Report tracks the growing and accelerating importance of science, technology and innovation (STI) for economic and social development over the last 25 years. It also highlights the pervasiveness of technology in the home and workplace and the impact on the quality of life through the ever-increasing pace of industrial innovation.

It demonstrates the importance of ensuring that policies and programmes for science, technology and innovation have a clear unity of purpose. They should not only be well-based individually but should also form a coherent whole in order to maximise their contribution to economic growth and social development.

The 'Innovation System' Approach

In looking at Ireland, the Report draws on the concept of a *'National System of Innovation'*. This was defined, as "the collection of all institutions and mechanisms (public and private) that interact to stimulate and support innovations in products and systems in the national economy".

The National System of Innovation (NSI) model also encompasses broad cultural and attitudinal themes, for example the environment for research and technological development in Ireland; aspects of the education system (appreciation of science and technology at primary/second level; funding and application of research at third level); the perception of science and technology among the general public, the business sector and policy makers in the public and private sectors. Finally, the model extends to interactions and feedbacks between the NSI in the narrow sense and other aspects of public policy and national institutions: private

sector financing of innovation; tax treatment of research and development; and the role of the State in funding and supporting a balanced portfolio of programmes for research and technological development.

Developed in the Nordic countries, this model has been highlighted in previous National Economic and Social Council (NESC) reports. It has been persuasively argued that it throws significant light on why Ireland's development performance is so poor *vis a vis* relevant peer countries and economies and, indeed, the wider world.

The analysis based on applying the model of a National System of Innovation to Ireland attributes poor relative development performance to the presence, over a long period, of a series of interlocking, inter-related and cumulative vicious circles. In essence we have a weak National System of Innovation.

Among the key conclusions of the TIERNEY Report are that:

- there is a low level of research and development in Ireland, particularly in the business sector. Furthermore, the economy generally buys in the innovations of others in order to upgrade technologically, e.g. through technology acquisition;
- there is a need to provide increased resources for those involved in "knowledge generation", particularly the third–level colleges, and to improve the interaction and knowledge transfer between the third–level sector and enterprises;
- there is a need to increase the level of understanding of the contribution of science and technology to innovation by business people and policy-makers;
- the ultimate objective of the national science and technology effort is to achieve a much higher level of innovation performance in industry and other sectors. This requires the co-ordination of both the private and public sectors; to that end, the Report proposes changes in policies and programmes in the areas of business, the third-level colleges and the public sector.

To address these issues, the TIERNEY Report makes some 160 recommendations.

The Report devotes particular attention to the institutional arrangements for STI policy analysis and determination. It lays emphasis on the need for a coherent strategy for setting national STI priorities and for the allocation of the substantial Exchequer funds spent on STI activities across a wide range of Departments and Agencies.

TIERNEY demonstrates that, by whatever yardstick is used, Ireland has featured badly in the international league tables on S&T. Total spending on R&D, as a proportion of GDP, is just over half of the OECD average. Business sector spend on R&D is about 70 per cent of its European competitors and spending on basic research is near the bottom of the league of competitor countries.

While there have been recent improvements in our performance, no nation, no sector or no firm, can sustain that position over the long term and remain competitive.

TIERNEY concludes that a new vision of innovation is needed, embracing the knowledge and skills generated through science and technology. However, Ireland's science and technology performance, the institutional arrangements

and the wider culture leave significant room for improvement. The Report calls, therefore, for a programme of planned, sustained and increased investment in research, development and technology application; significant institutional reform; and measures to raise awareness and appreciation of the role and importance of science, technology and innovation, the values of curiosity and enterprise, in pursuing our ambition of securing the sustainable good life for all. It is the aim of this Government to pursue this project.

FAMOUS IRISH SCIENTISTS

Kathleen Lonsdale (1903-1971)

The contributions of Irish men to the development of scientific knowledge is beginning to be recognised. But there were pioneering Irish women who made lasting contributions also, and they have largely been forgotten in the Ireland of today. One of the most eminent of these was Kathleen Lonsdale, who made fundamental contributions to X-ray crystallography – the study of the structure of molecules using X-rays. She was the first to demonstrate that the benzene ring, a vitally important structure in organic chemistry, was flat. She became, in 1945, the very first woman to be elected to Fellowship of the Royal Society.

This Dame Commander of the British Empire was born in Newbridge, Co. Kildare, the tenth child of the local postmaster. The family moved to Essex in 1908, where Kathleen had to go to physics, chemistry and higher maths classes in the local boys' school as these subjects weren't on offer at her own school. She was always good at sums, an ability she reckoned she inherited from her father. At sixteen, she went on to Bedford College in London and, while still in her teens, again beat the boys by coming top in her honours BSc exam in 1922.

She worked in London with the famous Nobel Prize winners, Sir William and Sir Lawrence Bragg. But her career was in danger of ending when she married Thomas Lonsdale, moved from London to Leeds, and considered giving up science to be a good wife and mother. Thomas would have none of it. He hadn't married, he said, to get a free housekeeper.

It was at Leeds, in 1929, that she studied crystals of hexamethyl benzene and showed that the molecule was flat. Back in London, she became Professor of Chemistry at University College.

As well as being the very first woman to be elected to Fellowship of the Royal Society, she was also the first woman President of the British Association for the Advancement of Science.

She spent a time in jail in 1943 for being a pacifist. When she later became a prison visitor, she was able to use her experience as an inmate to empathise with those in detention. The Empire had presumably forgotten or forgiven her pacifism when they appointed her a Dame.

It is a remarkable story of success for the postmaster's daughter from Newbridge.

The Government's Response and Priority Actions

"We hope that Government will provide a rapid response to our Report and that its decisions will be published in a White Paper on S&T. We recognise that this process will require a lot of examination and consultation with the various Departments, Agencies and institutions concerned. This will take time, yet we strongly believe that Government should publish its policy with minimum delay."

TIERNEY Report, Page 171

Introduction

In May 1995, within three months of publication of the TIERNEY Report, the Government decided to accept the basic precept of the TIERNEY Report that a strong National System of Innovation, based on the creative application of science and technology, is a key element in achieving sustained industrial, social and economic development, and the creation of high added-value exports and skilled employment.

The Government established a Cabinet Committee, chaired by Mr. Pat Rabbitte TD, Minister for Commerce, Science and Technology, to consider the findings of the TIERNEY Report and also established an Inter-Departmental Task Force to prioritise and examine how best to bring forward the recommendations for implementation.

The Task Force was chaired by Mr. John Travers, Chief Executive of Forfás – the national agency for STI policy advice and co-ordination. The Task Force included representatives from the four key Government Departments concerned with the implementation of the recommendations:

- Department of Enterprise and Employment – Mr. Michael Fahy
- Department of Education – Mr. Paddy McDonagh
- Department of Finance – Mr. Michael Cunniffe
- Department of Agriculture, Food and Forestry – Mr. Jim Flanagan

Other Government Departments participated when issues relevant to their remits were under consideration.

The Task Force also included Mr. Dan Tierney and Professor Dervilla Donnelly, chairman and member of STIAC respectively. This ensured consistency and continuity with the work of the Council. The terms of reference of the Task Force are set out at Appendix 1. The Task Force was greatly assisted in its deliberations by submissions from a number of interested parties and by the outputs from conferences and symposia organised to discuss the STIAC recommendations.

The Cabinet Committee and Task Force wish to record that they were particularly well served by the secretariat resources provided by the Office of Science and Technology and Forfás.

The Work of the Task Force

The Task Force examination of the TIERNEY Report was undertaken against the background of the wide range of consultancy and secretariat reports at STIAC's disposal and also against the background of a number of national and international public policy documents and initiatives relating to enterprise strategy, competitiveness, education and public service management as they impact on science, technology and innovation (see Appendix 2).

In considering TIERNEY, the Task Force examined each of its 160 recommendations. In order to provide a coherent structure for implementation purposes, the Task Force dealt with the principal recommendations under eight major headings:

- National S&T Strategy and Structures;
- Innovation in Enterprises;
- Technical Services for Enterprises;
- Support for Natural Resource-based Sectors;
- Programmes in Advanced Technology;

- Third-Level Research and the Role of the Colleges;
- Improved Education and Training;
- Improved Awareness of Science, Technology and Innovation.

Action To Date

Since the publication of TIERNEY, and in the light of the ongoing work of the Cabinet Committee and Task Force, the Government has already taken action on a number of specific recommendations as described below:

- **taxation –** the 1995 and 1996 Finance Acts provide for a 400% deduction for incremental R&D expenditure; also in 1995 the Business Expansion Scheme was extended to shares in companies providing R&D services to other companies;
- **basic research** expenditure was increased from £1 million to £1.5 million in 1995 and to £2 million in 1996;
- **strategic research** funding was increased in 1995 and again in 1996;
- funding was increased for **college/industry applied research;**
- the **National Research Support Fund Board** was established as an independent body to administer an open and transparent scheme to support third-level basic and strategic research;
- increased funding was provided for **technology brokerage** in 1996;
- increased funding was provided for the **'Techstart'** Scheme to place graduates in firms;
- the annual **PhD support** grant has been doubled to £2,000 per annum;
- funding has been provided in 1996 for a new **post-doctoral fellowship scheme;**
- additional funding was provided to expand the **company technology audit scheme** to include design and product development capability;
- funding was provided for a programme, to be piloted in 1996, to encourage **inter-firm collaborative networks;**
- increased funding was provided for **regional technology service centres in 1996;**
- funding has been provided for a new **international research collaboration scheme;**
- an **STI Awareness Programme** was initiated in 1996;
- an **R&D Management Development Scheme**, to provide training in R&D and innovation management for companies, was launched in 1996.

Most of the above actions were funded out of an additional allocation of £4 million in the 1996 Budget, which was provided to begin implementing the priority recommendations. In addition to the £4 million allocated to the Department of Enterprise and Employment, the Departments of the Marine and Health also provided increased funds for research to agencies under their control.

Also, the Structural Funds Research & Technological Development (RTD) Co-ordinating Committee was established in 1995. This Committee acts as an advisory and co-ordinating group and its remit is to cover all research and technological development activities across all Departments and agencies involved in the various Structural Fund Operational Programmes.

Areas for Priority Action

The TIERNEY recommendations cover a wide array of issues which impact on the National System of Innovation. The following Chapters examine these themes, presenting the STIAC case and the Government's views and decisions. Only a minority of these decisions require direct Government intervention. The others involve the development agencies (mainly Forbairt and Forfás), the Universities, Regional Technical Colleges, other State organisations and industry.

The Task Force also determined a programme of priority actions. The main features are detailed below.

1 **The Government will establish an Inter-Departmental Committee to work with the existing Cabinet Committee for science and technology, to ensure a coherent and comprehensive approach to the design, delivery and evaluation of STI policies and programmes.**

As part of the annual Estimates and Budgetary cycle, a planning process for science and technology will be established under the aegis of the Cabinet and Inter-Departmental Committees. The process will analyse current State investment in science and technology and comment on the spending plans of Departments and agencies, as provided for in the Forfás legislation. It will also identify national research priorities.

2 **A permanent STI Advisory Council, representative of wide-ranging interests, will be established.**

3 **Recognising the role of basic research, the Government has provided extra funding in 1995 and 1996 to strengthen the research capability in universities and technical colleges. In addition, the Government has doubled the annual scholarship grants for PhD students (from £1,000 to £2,000), introduced a new support scheme for post-doctoral students (at a rate of £20,000 per annum for 2 years) and provided extra funding for international research collaboration.**

4 **The Departments of Finance and Enterprise and Employment will carry out a review of the efficiency and effectiveness of the tax regime as an encouragement to invest in R&D.**

5 **Forbairt will launch a sustained effort to raise the profile and increase the use of technology transfer, as an important complement to R&D, in contributing to industrial innovation. Maximum collaboration in this endeavour will be established with the other State agencies and programmes which have a technology transfer function, with the universities and especially with the RTCs/DIT, in view of their key role in regional economic development.**

6 **To increase the technological activities and capabilities of indigenous small and medium firms, extra funding has been provided to expand and develop the Technology Audit and Technology Placement Programmes. Technology Audits will be extended to include design and to place greater emphasis on**

product development. 'Techstart' placements will be increased initially from 215 at present to 300 per annum.

7 Forbairt has been instructed to launch a programme of inter-firm collaboration, aimed at networking activities of firms. A pilot programme will be introduced before the end of 1996. The objective is to bring firms together to co-operate in strategic areas such as R&D, so as to overcome the disadvantages of the small scale of their individual operations.

8 The Department of Enterprise and Employment and Forbairt will monitor the new £60 million Seed and Venture Capital Fund to establish if there are special barriers for technology-based companies, which need to be addressed.

9 The Programmes in Advanced Technology (PATs) will be established as a company. The company, which will implement policy and strategy laid down by the Minister, will be formed as a subsidiary of Forbairt, in consultation with the Minister for Commerce, Science and Technology. The Minister will also establish a standing Board to address PATs policy and strategy and annual funding decisions for the individual PATs, to prioritise between them – including closure of PATs and establishing new ones – and to advise the Minister accordingly. The Board will be representative of third-level, industry and State interests in the PATs.

10 The Government has decided to provide financial support for a three-year professional campaign, to be organised by Forfás, which will promote improved awareness of the importance of science, technology and innovation. The campaign, commencing in 1996, will be targeted particularly at decision-makers in the public and private sectors and also at the education and business sectors, the media and the general public.

HOW SCIENCE, RESEARCH AND TECHNOLOGY HAVE IMPACTED ON MY LIFE AND WORK

Gerald Fleming, Met Éireann

I was born and raised into a scientific milieu. My father worked as a research scientist with An Foras Taluntais, my mother had worked there before marriage, and most of my brothers and sisters have subsequently pursued careers in science or engineering.

The study of Physics at third level brought me some familiarity with the great developments in that subject during the early decades of this century. I believe that these developments rank among the great intellectual achievements of mankind, and are all the more impressive in that they represent the combined achievement of many talented persons.

My own work in meteorology has brought me into a dynamic and rapidly changing field. The tools we use to observe and measure the weather have changed, within decades, from brass barometers and alcohol thermometers to automatic weather stations, high-definition radars and remote sensing from satellite. Fast data links allow us to collect and store all this information efficiently. The power and sophistication of the computer models we use to make sense of the information increases monthly. And then there is the explosion in broadcast graphic technology, which allows us to better explain the forecast on television. Ten years ago the television weather map was drawn with black marker on a cardboard base. Now our graphics system is computer-based, allowing us to concentrate on the detail of local weather.

I could not even begin to guess what changes are in the offing during the next decade, but I do believe that a solid educational background in science is increasingly necessary in keeping abreast of changes in technology.

National S &T Strategy and Structures

"In our Report we have stressed that the Government has to be convinced that it is getting the best return from its investment before it is persuaded to invest more. This raises issues such as the way Government organises S&T business overall – whether it has the right mechanisms in place to ensure that there is a clear strategy for S&T spending across Departments and agencies."

TIERNEY Report, Page 159.

This Chapter deals with the necessary structures in Government which will provide a coherent national S&T strategy and determine national R&D priorities.

Decisions of the Government

- The Government will develop an integrated procedure for the prioritisation of S&T spending, based on the Forfás annual Science Budget and draft spending plans of Departments. The process will form an integral part of the annual Estimates and Budget cycle.
- The process will be conducted by an Inter-Departmental Committee under the direction of a Cabinet Committee. The Minister for Commerce, Science and Technology will establish terms of reference and modus operandi of the Inter-Departmental Committee.
- Forfás will make proposals on the function, scope and optimum process for a techno-logy foresight or alternative process for generating future techno-economic scenarios as an input to the prioritisation process.
- Each Department will designate an Assistant Secretary (or equivalent rank) with responsibility for promoting and co-ordinating its science and technology policy and budgets.
- The Office of Science and Technology (OST) will have responsibility for national co-ordination of STI policy which function will remain as part of the Department of Enterprise and Employment.
- A permanent STI Advisory Council, representative of wide-ranging interests, will be established.
- Funding for science and technology, on a programme basis, will increase in line with priorities, when proven and as resources permit.
- The Government will commission a study of the implications for science and technology funding and alternative sources, post-1999 Structural Funds.

Introduction

No nation can afford to undertake all of the scientific research and technological development it would like. Choices have to be made. Priorities have to be set in line with wider policy objectives for national development. Funding must be allocated in accordance with these priorities. Any other arrangement means limited funds are not being deployed to best effect. This implies a need for a conscious focus on S&T.

TIERNEY expressed surprise that there is no budgetary process for determining, in advance, how much the Government is spending on S&T and how it is being allocated. These data are collected after the event by Forfás. The total allocation to Government S&T initiatives in 1996 (in accordance with common international definition) is estimated at £780m. While a large portion of this goes on non-discretionary activities, such as for undergraduate teaching, in S&T disciplines, or routine testing in health laboratories, the discretionary amount is still large enough to require that

it be deployed in a coherent way to where it can do most good. In 1996, about one-third (£260m) of the S&T allocation is in support of enterprise and natural resource and environmental development.

The Report saw the need for a Government planning process with a long-term vision of the country's S&T requirements. It also emphasised the need to clearly link S&T policy and programmes with industrial policy and wider economic and national development.

The TIERNEY Report advocated a co-ordinating mechanism at central Government level to ensure efficiency of spending, value for money and, above all, a coherent approach across the 12 Government Departments and over 30 Government agencies which dispense S&T funds.

To be truly effective, this mechanism would also require:

(i) technology foresight inputs (increasingly being used in other industrialised countries) to scan for emerging technology trends of critical importance to the competitiveness of industry;

(ii) inputs from a national science and technology advisory body drawn from the scientific community, industry and other organisations;

(iii) political direction to ensure that scarce Government funds are being committed according to a coherent strategy which addresses changing national needs.

Finally, TIERNEY believed that the process, by its nature, would result in a much higher profile for, and appreciation of, science and technology which would contribute to the achievement of its full potential.

In summary, the Report recommended that:

- new **national S&T structures** should be put in place. An annual S&T plan should be published. The plan would be prepared by an Inter-Departmental Committee, chaired by the Minister for Science and Technology and serviced by the Office of Science and Technology. A Cabinet Committee, chaired by the Taoiseach or his nominee, would deal with S&T matters, particularly Estimates and national S&T priorities;
- current Forfás legislation should be fully utilised, as intended, as a basis for a comprehensive and **coherent approach to S&T spending** and to advance a process of prioritisation;
- in order to secure **inter-departmental co-ordination**, S&T activities in each Government Department should be co-ordinated under a Divisional head (at Assistant Secretary rank). S&T funding should be consolidated into a single budget for each Department, voted separately by the Oireachtas;
- as regards the **Department of Enterprise and Employment**, responsibility for S&T matters should stay in the Department. The Department's title should include "Innovation". There should be a Minister of State exclusively for STI. All S&T matters in the Department of Enterprise and Employment should be brought within the Office of Science and Technology (OST), under the Minister of State. The OST should be upgraded to a National Office of Science, Technology and Innovation to manage all the Department's S&T activities and to facilitate inter-Departmental co-ordination and

the formulation of a national plan for STI;

- a permanent **Science, Technology and Innovation Advisory Council** should be established to provide independent expert advice on STI policies. It should have statutory backing and be supported by Forfás;
- in addition, TIERNEY addressed the question of **funding** and additional financial resources for science and technology.

National S&T Structures

The Government accepts that, because of the size, importance and wide spread of State investment in S&T, organisational structures are required which will devise a long-term strategy for S&T; facilitate planning of S&T spending; and ensure efficiency and value for money. These reforms are rendered all the more important because of the critical impact which S&T spending can have on economic and industrial development and in view of the comparatively low levels of S&T spending in Ireland. Above all, given our limited resources, our ambition to build a strong National System of Innovation and S&T's role in this project, priorities must be established as to where and how S&T funds should be allocated.

The Government accepts the recommendation that a plan for science and technology spending should be drawn up on a rolling annual basis, incorporating all Departments and agencies, and including targets and indicators, monitoring, evaluation and commentary. This reform is in line with the planned change in approach to public expenditure programming in general. From 1997, the annual Estimates will be framed within a three-year rolling programme. The plan should be published and debated by the relevant Oireachtas Committee, in order to raise the profile of science and technology within the democratic-political dimension to policy formation.

The plan will be drawn up under the direction of a permanent Inter-Departmental Committee of civil servants of all S&T spending Departments. This Committee will be chaired by the Minister responsible for Science and Technology and serviced by the Office of Science and Technology at the Department of Enterprise and Employment, supported by Forfás. Departments will be represented by the Assistant Secretary or equivalent rank responsible for co-ordinating S&T activities.[6.7]

The planning exercise will be overseen by the present Cabinet Committee appointed to deal with S&T matters. In particular, it will settle Budgetary/Estimates matters and establish national priorities, as happens in a number of other industrially advanced countries. The Committee will be chaired by the Taoiseach or, when not available, by his nominee.

The Government accepts the logic of the situation that to prioritise S&T expenditure and to take conscious decisions on how to allocate S&T funding, it is necessary to identify S&T spending proposals at the annual draft Estimates stage, for commentary and consultation; and to subsequently publish S&T spending allocations as a consolidated Science and Technology Budget.

The Forfás legislation enables this to be done, but to implement it effectively new arrangements are necessary as part of the annual Estimates campaign.

The Government has decided that S&T spending proposals should be presented as part of the Estimates, in the form of an annex to each

Department's Vote.

This will allow for the consolidation and identification of S&T spending *beforehand*, provide a year-to-year comparison of the level of spending, encourage the setting of priorities within Departments and provide a basis for the Inter-Departmental Committee to establish a strategy for the setting of national S&T priorities. The inclusion of S&T expenditure as a programme, annexed to each Vote in the published Book of Estimates, will provide the full transparency required by the TIERNEY proposals and will help to spotlight S&T activities.

The planning process will operate in tandem with, and as an integral part of, the annual Estimates exercise. While the purpose of the planning exercise is to focus coherently on S&T spending across Departments, agencies and programmes, and to establish national priorities, final decisions on Estimates are a matter for the Government of the day, as part of the Budgetary process. The planning exercise will be of considerable benefit and support to the Department of Finance and the Government in this task.

Finally, as noted by TIERNEY, an essential part of the planning process is the rigorous evaluation of programmes and activities and the publication of their findings. The Government endorses this view. It also accepts that the process would be strengthened by a technology foresight exercise to evaluate emerging technologies and their implications for Ireland's international competitiveness. The Programmes in Advanced Technologies (PATs) are partly performing this role at present but we need additional mechanisms to focus on newly developing niches.

Government Decisions

With an ambition to build a strong National System of Innovation, the Government will adopt an integrated process for prioritising S&T spending, based on the Forfás annual Science Budget and draft spending plans of Departments. The process will form an integral part of the annual Estimates and Budget cycles. The process will be conducted by an Inter-Departmental Committee under the direction of a Cabinet Committee on science, technology and innovation.

The Minister for Commerce, Science and Technology will immediately establish terms of reference and modus operandi of the Inter-Departmental Committee.

Forfas will make proposals on the function, scope and optimum process for a technology foresight or alternative process for generating future techno-economic scenarios as an input to the prioritisation process.

Co-ordination of S&T at Departmental Level

If the proposal to develop a coherent strategy for S&T spending and prioritisation is to achieve its purpose of creating a strong National System of Innovation, the supporting proposals – such as co-ordination of S&T within Departments, separate S&T budgeting, implementation of existing legislation, monitoring and evaluation and independent expert advice – must be implemented as a package.

The Government accepts the recommendation that all S&T activities in each Department should be co-ordinated at Assistant Secretary or equivalent level. This can be achieved in a pragmatic way and in a manner best suited to the

organisation and structure of individual Departments.

Government Decision

Each Department will designate an Assistant Secretary or equivalent rank with responsibility for promoting and co-ordinating its science and technology policy and budgets.

Department of Enterprise and Employment

The Government fully supports the TIERNEY conclusion that national S&T policy should remain a function of the Department of Enterprise and Employment. This is in order to underline its importance in economic development, job creation and the National System of Innovation. Since the mid-1980s there has been a greater orientation of science and technology policy and programmes towards meeting the development needs of the economy and, particularly, to emphasise their role in industrial development. These developments have underlined the fact that, at policy level, S&T is central to economic and industrial development; at the operational level, technological development is integral to company development and, at firm level, technological capability is central to innovation.

At the same time, this approach has been underpinned by significant new funding from EU Structural Funds, as part of the Operational Programmes for Industry 1989 - 1993 and 1994 -1999, which have provided for a total investment of over £600 million in S&T programmes over the period.

The Government considers it vital that the Office of Science and Technology (OST) should have responsibility for S&T policy within the Department of Enterprise and Employment, to ensure consistency of approach across all activities. The OST should also act as the central co-ordination point for national S&T policy in its supporting role for the national planning process.

Government Decision

The Office of Science and Technology will have responsibility for national co- ordination of STI policy and this function will remain as part of the Department of Enterprise and Employment.

STI Advisory Council

The Government accepts that there is a need for strong and objective advice on S&T matters, given its impact in a wide range of areas. This should be provided by an independent body, capable of expert advice on STI policies and programmes and on the achievement of a healthier National System of Innovation. This body should be free to offer advice to Government, on its own initiative or in response to specific requests, and should provide a channel for advice to Government from other STI interests. Its advice should contribute to the prioritisation process and should form an ongoing input to the national S&T planning process.

The TIERNEY recommendation to establish an independent, permanent STI Advisory Council would require legislation. At present, the function under the Science and Technology Act, 1987 (see Appendix 3) to advise the Government on policy for S&T-related matters, is vested in Forfás. The Government has, therefore, decided that, while this Council will be established by the Minister for

Commerce, Science and Technology, and will report to him, it will be implemented under the provisions of the 1987 Act. The Government has asked Forfás to submit proposals to the Minister.

Government Decision

The Government has decided to establish an STI Advisory Council, representative of wide-ranging interests.

Funding of STI

The above recommendations, while having some indirect financial implications, were not costed by TIERNEY.

Other recommendations called for direct State spending. They were costed by TIERNEY and a phased implementation was outlined. It pointed out that it did not attempt to identify savings within S&T budgets, or how reallocations of funds from other areas might help finance its proposals. It, nonetheless, sought a sum of £25m towards the more critical areas in the short-term and to "kick-start a new attitude to S&T". In the longer-term, TIERNEY pointed out, the process of advance planning and prioritisation would allow a shift of resources within S&T budgets. TIERNEY also expressed concern that Ireland's S&T system is too dependent on support from EU Structural Funds.

The Government accepts the TIERNEY view that a short-term injection of funds or "quick-fix" approach will not, of itself, resolve the underlying problems facing the Irish science and technology system. The structures recommended by TIERNEY are designed to put in place a system which will ensure long term attention to science and technology policy and the adequate funding of activities deriving from that policy. That process may, over time, provide for new funding, transfer of resources from non S&T areas into S&T, and re-orientation of S&T expenditure within existing budgets.

In keeping with the expressed priorities of the TIERNEY Report, a start was made in 1995 and 1996 to provide extra funding and incentives. The details are set out in Chapter Five.

In the case of some of the recommendations, it is possible to implement them incrementally or as part of existing schemes. When the planning process described earlier is in place, there will be a systematic means of deciding on additional funding for S&T and, when proven, where it should go. The Government will examine any such proposals put to it. The Government accepts that EU Structural Funds now form the bulk of the discretionary public financing going into STI in Ireland. It considers that there is an urgent need to address future funding sources in the context of a possible diminution of EU funding when the current round of Structural Funds ends in 1999.

Government Decisions

The Government agrees that if the Irish economy is to compete effectively in an era of rapid technological change, then our S&T investment must be internationally competitive. However, that is a macro view, is only part of the picture and is certainly not a scenario that can be achieved overnight. The State already invests large sums of money into an array of S&T activities. There is a growing awareness, and hence welcome competition for State funding. The long-

term objective is to channel the total and considerable S&T spend into areas where it is most productive and to engender competition between all the areas which seek State funds.

The Government will increase funding for science and technology on a programme basis, in line with priorities, when proven and as resources permit.

The Government will commission a study of the implications for science and technology funding and alternative sources, post-1999 Structural Funds.

FAMOUS IRISH SCIENTISTS

William Thomson, Lord Kelvin (1824-1907)

One of the greatest of all nineteenth century physicists was William Thomson. It is not always appreciated that he was of Irish birth. But his family background in Belfast played a very important part in his outlook on life and his approach to science, for he was no ivory tower theorist, but a man of remarkable intellect who addressed and resolved many practical challenges of industrial relevance. Of his numerous contributions to science and industry, he is particularly remembered as being the brains behind the first successful transatlantic telegraphy cable of 1866. And the "absolute" scale of temperature is called after him, the freezing point of water on this scale being 273.15 degrees Kelvin.

The first transatlantic cable, laid in 1858, was a failure, largely due to poor insulation and to the large voltages which were used. Thomson invented a very sensitive mirror galvanometer which could detect extremely feeble signals, and this was the essential element in the successful cable of 1866, which ran from Valentia Island to Trinity Bay, Newfoundland. He received his knighthood for this work.

William Thomson has another claim to nautical fame. He improved compasses for navigation, and his new compass was adopted by all British Navy vessels. He formed a working relationship, and later a company, with the Glasgow instrument maker James White, and together they produced and sold a new generation of precise electrical and other instruments patented by Thomson. He accumulated great wealth through his patents and business interests.

William didn't always get it right. Based on the cooling of the earth, he estimated in 1846 that the age of the earth was about 100 million years. Another Irishman, John Joly (1857-1933), using radioactive decay in minerals, played a key role in establishing that it was much older – about 4,500 million years.

Innovation in Enterprises

"No company can rely for long on a single product, no matter how profitable. Competitors will imitate it, improve on it and beat it in the marketplace. If an enterprise is not investing in R&D to renew its products, it is actually going backwards. It will not disappear overnight – it stagnates – going into slow decline. This is one of the main reasons why Ireland is finding it so difficult to grow new companies beyond a certain size. In many respects Irish indigenous industry is "just surviving" and not investing in innovation."

TIERNEY Report, page 63

Innovation is ultimately a matter for the business sector. This Chapter deals with science, technology and innovation for individual enterprises, for the industries in which they operate and deals with the promotion of networking between enterprises.

Decisions of the Government

- Forbairt will introduce a programme to encourage inter-firm collaboration and networking. A pilot programme will be introduced before the end of 1996. The objective is to bring firms together to co-operate in strategic activities such as R&D, so as to overcome disadvantages of small scale.
- Forbairt has been directed to develop a national technology brokerage activity by extending the role of the Technology Transfer Programme and co-ordinating the Agency's other programmes which have a technology brokerage function. The Programme will also liaise with other Agencies, such as Teagasc and ABT, in rela-tion to their technology transfer activities.
- The Departments of Finance and Enterprise and Employment will carry out a review of the efficiency and effectivness of the tax regime as an encouragement to invest in R&D.
- Forfás will review means of further encouraging multinational companies to increase their product and process development and other R&D in Ireland, to draw on domestic sources of technological support and to transfer their technological expertise to indigenous companies.
- The Department of Enterprise and Employment and Forbairt will monitor the new £60 million Seed and Venture Capital Scheme to see if there are special barriers facing technology-based companies which need to be addressed.
- The Techstart graduate placement programme is being increased, initially, from 215 places in 1995 to 300 places this year, after which the situation will be reassessed.
- The Technology Audit Programme will place greater emphasis on product design and development.
- Forbairt's Intellectual Property Unit will be strengthened to assist small firms engaged in patenting and to provide promotional material on the creation, protection and exploitation of patents.
- The Government has instructed Forfás to convene a meeting of all State procurement and development agencies to devise mechanisms to provide product development opportunities for Irish firms involved in public procurement, within the context of EU legislation.

Introduction

The sustained and continuing high annual growth rates registered by the Irish economy have prompted many commentators to the description of Ireland as a 'celtic tiger'. However, impressive growth performance at the macro level masks differential performance and a dualistic structure. The persistence of dualism and a low-performing, mainly indigenous, business sector – what some commentators have characterised as the 'celtic tortoise' – is a source of concern.

One of the main distinguishing characteristics of this dualism is the extent to which the fast-growth sector embraces science, technology and innovation and competition, and accepts the challenge of globalisation.

Another important distinction between the two sectors is between foreign-owned and indigenous firms. Foreign-owned companies located here tend to be in high-technology sectors and to use advanced processes and systems. These are an important source of knowledge within the State. They have helped to raise quality standards in domestic suppliers and have provided a source of entrepreneurs to set up new, technically-advanced enterprises. There are, today, a growing number of indigenous firms that have absorbed the values, techniques and business approach of the foreign-owned sector. However, the basic foreign/indigenous dichotomy unfortunately remains valid.

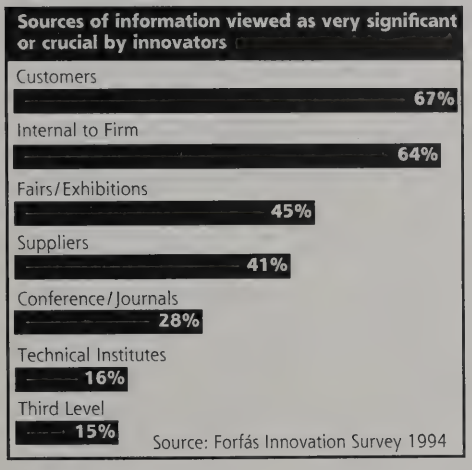
Finally, while there are exceptions, indigenous enterprises tend to be small, without an adequate return on capital employed and located in traditional industrial sectors, such as clothing and food. Foreign-owned firms, while larger and more successful, have tended, for the most part, to be branch manufacturing or assembly plants with quite shallow roots in the local economy which carry out their R&D and other business functions elsewhere. While there have been welcome signs that this may be starting to change, action needs to be taken to strengthen links between both of these industrial groupings and the National System of Innovation. While this White Paper concentrates on innovation derived from science & technology, the wider aspects of the importance of innovation in industrial development will be addressed in the Enterprise Strategy Paper to be published in the coming months by the Minister for Enterprise and Employment.

The dualism of the Irish economy, the dichotomy between high and low performers, is clearly reflected in differential and pronounced levels of participation in research and development and innovation and also in a high dependency on technology transfer, which is to say the innovation of others. However, it is important to emphasise the role of technology transfer as a mechanism for acquiring and using new knowledge, particularly in the short to medium term. Indeed, the development of a firm's internal capacity to engage in R&D and a technology transfer approach, should be viewed as complementary, rather than alternative, strategies for innovation.

Only one-quarter of Irish companies perform R&D on a continuous basis but the 1994 Forfás Innovation Survey found that 42% of innovating enterprises were involved in buying-in technology from outside the company. The main means by which this was done were: purchase of

equipment (28%), acquisition of patents and licences (15%), hiring of skilled people (15%) and the use of consultants (13%).

The Innovation Survey also asked about sources of knowledge and information for innovation in enterprises. The following chart shows the sources rated as very significant, or crucial, for innovators.



There is clearly a considerable amount that could be done to improve interaction between enterprises and sources of technological knowledge and expertise, both within and outside the State.

There is evidence that enterprises benefit from trade fairs and exhibitions (45% see them as a very significant source of knowledge). More needs to be done to bring this message to less innovative firms and also to increase interaction with other sources of technology outside the State.

In particular, significant barriers exist to the effective transfer of knowledge from the third-level sector to enterprises. Business is not convinced about the commercial applicability of knowledge available in colleges, and many academics consider that there is a low capacity in many Irish firms to absorb technological information available from colleges and other sources. This issue is dealt with in Chapters Ten and Eleven (which deal with the Programmes in Advanced Technology and Third-Level Research and the Role of the Colleges).

The TIERNEY Report viewed technology policy as being aligned to – indeed a core element of – industrial policy. A failure to act on this – despite its recognition in earlier reviews of our industrial policy – has been a fundamental weakness of Irish industrial policy in the past and has been a key factor in the evolution of the long-recognised and persistent dualism in Irish industry.

The Report identified key problems to be addressed as:

- the small size and scale of Irish firms;
- the low technology base of most Irish firms;
- low levels of commitment to R&D, especially in the indigenous sector;
- low levels of innovation and entrepreneurship;
- lack of integration of multinational enterprises (MNEs) into the economy.

It proposed a number of initiatives to address these problems, among which the major priorities are dealt with in the following paragraphs.

Much of the emphasis in the TIERNEY Report, and in national science and technology policy in general, is on research and development and its encouragement at enterprise level, through incentives, support measures and technical services. In terms of our 'contractarian' philosophy, with its emphasis on intrinsic goals, and the instrumental means to achieve these ambitions, this is appropriate given the relatively low level of R&D in Ireland and its importance in the innovation process.

The Problem of Scale: an Inter-Firm Co-operation Programme

The first initiative proposed by TIERNEY was an inter-firm co-operation programme, modelled on the Danish system, which would bring enterprises together in co-operative networks and help offset the small size and scale of most indigenous firms. It would also help enterprises with common technological problems – but little in-house capability – to come together to develop joint solutions.

The Government endorses this idea, noting the range of such programmes operating in other countries. However, any such programme for Ireland would need to be designed to meet the specific requirements and characteristics of Irish firms.

Government Decision

Forbairt will introduce a programme of inter-firm collaboration, aimed at networking activities of firms. A pilot programme will be introduced before the end of 1996.

Technology Base: Enterprises with Minimum Technology

The TIERNEY Report saw a need for greater efforts to boost the performance of small enterprises with low levels of technological capability. This is necessary if small firms are to be fully integrated into the National System of Innovation and the system itself is to be strengthened – our long-term ambition.

Existing strategy is a mixture of raising awareness and competence levels in firms, by encouraging them to take on qualified technologists via subsidised technical placement schemes, and increasing their understanding of their own problems and shortcomings through the use of Technology Audits.

The Government endorses the recommendations aimed specifically at increasing the technological capability and innovation performance in smaller enterprises. However, it feels that the TIERNEY proposal to increase Techstart placements from 200 to 500 per year is too ambitious and could interfere with the natural functioning of the labour market.

Government Decision

The Government agrees that the development agencies, via their regional offices, have a key role in helping lower capability companies to improve their performance. The technical placement schemes, especially the Techstart Programme, will be expanded. The Government has made £700,000 additional funding available in 1996 for technology placement schemes. The Techstart Programme will be increased initially from 215 places in 1995 to 300 places this year, after which the situation will be reassessed.

Technology Base: a National Technology Brokerage Activity

The TIERNEY Report made a number of recommendations which relate to improving technology transfer into Irish industry from sources inside and outside the State. The key proposal is that the State should provide a mechanism to encourage and support knowledge transfer activities and to co-ordinate the range of technology transfer activities currently in place. TIERNEY considered that this could best be done through a brokerage acti-vity to facilitate the networking and interpersonal contact that is the basis for effective transfer.

The Report recommended that Forbairt should establish a National Technology Brokerage Activity, with three main functions:

- to promote and encourage technology transfer activities by enterprises;
- to facilitate these transfer activities and companies' ability to absorb the technology;
- to scan world-wide developments in technology and make the findings widely available to industry.

The Government agrees that the degree to which information and technology transfer takes place is a weakness in the Irish innovation system. Agencies need to be more active in this area. There is a need for better co-ordination of the technology acquisition and transfer activities of State agencies, with the clear objective of increasing the transfer of technology into Irish companies. For example, in addition to Forbairt, ABT through its market research and intelligence, should make a strong input into ensuring that R&D investment delivers market-led products and innovations.

As well as the more recently introduced R&D Grants Scheme (Measure 1), a separate Technology Acquisition Grant Scheme – intended to assist enterprises with technology transfer activities – has been available to industry for some years. Unfortunately, awareness of this mechanism is extremely low in industry and usage has been minimal. This Scheme should be actively promoted to Irish industry, and the complementary benefits of R&D and technology transfer properly explained.

The TIERNEY Report noted the significant increase in public sector investment in R&D for the food industry, under the EU-supported Non-Commissioned Research in Food Programme. It urged that this investment be matched by a similar programme which would give sustained support to technology transfer to the food processing industry.

The Government endorses TIERNEY'S recommendation that a special effort should be made to encourage technology transfer into the food processing industry, including marine-based food, in parallel with the major food R&D programme.

Government Decision

Forbairt has been directed to develop a national technology brokerage activity by extending the role of the Technology Transfer Programme and co-ordinating the Agency's other programmes which have a technology brokerage function. The Programme will also liaise with other agencies, such as Teagasc and ABT, in relation to their technology transfer activities.

Low Business Expenditure on R&D (BERD)

TIERNEY considered that, in order to bring BERD in Ireland into line with the EU average, it would be necessary to double the level of spend by 1999. It recommended that the Government should promote an increase in BERD by :

- continuing its own direct funding of business establishment of firms providing contract research and development services on a commercial basis;
- earmarking a proportion of the Measure 1 Scheme for R&D grants for new R&D performers, in both the indigenous and foreign enterprise sectors.

R&D Expenditure in the Business Sector as a % of GDP				
	1988	1991	1993	1995
EU Average	1.28	1.26	1.22	1.20
Ireland	0.47	0.62	0.84	1.00

Business Expenditure on R&D 1991 - 1995 (in current prices)			
	1991 Expenditure	1993 Expenditure	1995 (Estimate) Expenditure
All companies	£176m	£271m	£400m
Irish-owned	£65m	£91m	£140m
Foreign-owned	£111m	£180m	£260m

Government Decision

The Government recognises the importance of significantly increasing business R&D and the need particularly to bring on new R&D performers. There has already been a significant increase in BERD over 1991-1995. But the number of indigenous R&D performers still needs to be increased.

The Government considers it unnecessary to set a specific target for the level of direct State funding of BERD, as BERD will be driven by business and investment activities generally, as well as by a wide range of other TIERNEY recommendations, including indirect support via fiscal incentives and a programme to increase awareness of the importance of STI. Accordingly, BERD will be tracked and, if the required level of growth, at the micro and macro levels, is not happening, the Government will consider additional initiatives to stimulate the investment required.

The Government does not feel it necessary to earmark a proportion of Measure 1 funds to encourage new R&D performers or to set targets that are too rigid lest the quality of projects is undermined.

The Department of Enterprise and Employment will monitor the operation of Measure 1 to ensure that enterprises are using it to undertake additional and new R&D activity and that the number of R&D performers is increasing.

Fiscal Incentives

A number of the fiscal recommendations of the TIERNEY Report were implemented in the 1995 Finance Act. There is now in place an enhanced deduction (of 400%) for incremental expenditure on R&D, subject to certain conditions. In addition, the BES Scheme has been extended to shares in companies providing commercial R&D services. The Government notes that in many countries the taxation regime is an important element in encouraging investment in enterprise and innovation, including R&D. It is therefore an instrument which could be used as an effective means of inducing Irish firms to invest more in R&D.

Government Decision

The Departments of Finance and Enterprise and Employment will carry out a review of the efficiency and effectiveness of the tax regime as an encouragement to invest in R&D.

Integration of Foreign Industry

TIERNEY found that only 24% of multinationals in Ireland perform R&D here and felt that this proportion could and should be greatly increased and that MNEs should, in this way, be more fully integrated into the economy. The Government endorses the TIERNEY recommendations aimed at increasing the involvement of MNEs in R&D and other technological activities, their more complete integration into the National System of Innovation and the strengthening of the system thereby.

Government Decisions

The Government has instructed Forfás to review means of encouraging multinational companies to do more of their product and process development and other R&D functions in Ireland, to draw on domestic sources of technological support and to transfer their technological expertise to indigenous companies.

The industrial development agencies will also report annually on the proportion of their investment going to R&D, with a view to increasing the level of R&D spend by MNEs and the number of R&D performers.

Stimulating Enterprise: Venture Capital Funding

TIERNEY identified a need to establish a source of venture capital funding for high technology start-ups and growth companies. Irish investors are traditionally reluctant to invest in technology companies and the Dublin Stock Exchange has not met the needs in this area.

The Government emphasises the importance of access to risk capital for high-technology enterprises (including start-ups) and recognises the existing difficulties in obtaining such funding from conventional and established sources. It considers that this should be addressed in the context of a more general approach to facilitating access to capital for start-up and growth companies, and notes the allocation of funds for venture capital activities over the period of the Operational Programme for Industry 1994-1999.

The Government points out that such a fund has since been announced, valued at £60 million, shared between public and private sources. The fund will provide new equity funding for firms across a range of sectors, including high technology companies. Forbairt has responsibility for administering the fund which has already provided a separate venture capital sub-fund for the software industry, in association with ICC.

Government Decision

The Department of Enterprise and Employment and Forbairt will monitor the new £60 million Seed and Venture Capital Scheme to see if there are special barriers facing technology-based companies which need to be addressed.

Product Development

The TIERNEY Report pointed to a need for specific initiatives to increase the level of product

development in enterprises. Product innovation is the key to sales and employment growth. R&D is one mechanism to achieve it.

Other mechanisms include innovative product design, effective creation, protection and exploitation of intellectual property and the flexible use of public procurement funds to encourage local industry to participate more fully in supplying public sector requirements.

Government Decision

The Government has agreed the following measures aimed at encouraging and helping enterprises to undertake product development, apart from undertaking R&D:

- **the Technology Audit Programme has been extended to include support for product design and development; design proposals are now to be eligible for funding under the Industry R&D Measure (Measure 1) of the Industry Operational Programme;**
- **Forbairt's Intellectual Property Unit will be strengthened to assist small firms engaged in patenting and to provide promotional material on the creation, protection and exploitation of patents;**
- **the Government has instructed Forfás to convene a meeting of all State procurement and development agencies to devise mechanisms to provide product development opportunities for Irish firms involved in public procurement, within the context of EU legislation.**

A Case in Point – Biotrin Holdings Ltd

A Stillorgan-based company, Biotrin Holdings Ltd (BHL), was established in 1992 to develop and commercialise a range of unique proprietary biomarket assays (tests) for the assessment of organ damage to the kidney and liver, mainly associated with transplanted organs.

With more than 36,000 transplant operations performed each year, and 150,000 surviving recipients, the total market for transplantation products was greater than $2billion in 1994.

The company at present employs 52 people (41 based in Ireland) and has distribution companies in France and Germany and sales offices in the UK and USA. Its main strength has been the ability to develop and bring to the market novel proprietary products for the organ transplant and virology areas. Hepkit, a liver monitoring test system, has been on the European market for over two years and Nepkit, a kidney monitoring system, has recently been launched.

The start-up phase of the project was financed by Venture Capitalists and the development agencies. To date, the company has incurred anticipated losses which resulted from a very heavy spend in R&D (including clinical trials) and marketing (including the establishment of distribution channels) and were fully financed in advance by the investors. BHL has always operated on the basis of being adequately financed for all aspects of the operation including R&D, manufacture and sales/marketing.

The company is a young, fast-growing, highly focused biotechnology company producing products at the leading edge of technology

and, due to the specialised nature of the company, R&D is pivotal to it gaining and holding market share. It is critical it maintains a leading position in this market with the introduction of additional products to cover all aspects of the market niche.

This strategy has been strongly endorsed by both existing investors and new investors who have recently invested additional funds to finance the company's current development plan. The R&D programme involves the development of new products and marketing of the products in Europe, USA and the Far East.

IMPACT OF SCIENCE AND TECHNOLOGY ON MY WORKING DAY

Ann Riordan, Microsoft Ireland

The pace of change in information and communication technologies over the past twenty years has had a dramatic effect on my working day, particularly over the past five years. It is within the latter time frame that I have experienced the coming of age of the paperless office. Vast amounts of expensive office space, formerly used for paper storage and filing, have been freed up for more productive use. I am also now immersed in an e-mail culture - the impact this has made on my decision process has been dramatic. I work with 'virtual' teams around the world and have significant access to, and input from, some of the best minds in their relevant fields for decisions and strategies I implement locally. Wide area networks and access to information on a global basis not only benefit me personally but also our customers in Ireland. A presentation given by Bill Gates on new emerging technologies in Seattle, for example, can be given simultaneously in Ireland as his slides and notes are available to me on the 'net'. This saves time and protects us from reinventing the wheel, ensuring that Irish customers are as up to date on new technologies as any other around the world. We benefit from many competitive advantages working in a high tech organisation by using the latest information and communication technologies.

The uptake of the Internet has to be the phenomenon of our time, leading to what people are calling the information revolution. Today, more money changes hands in a single day on the global market than was transferred in an entire year, fifteen years ago. Large businesses have had access to this enabling technology by means of their own private networks for some time. However, I believe that small and medium size businesses can now compete with the largest organisations if they embrace this technology and work with 'virtual' partners on a global basis.

Technical Services for Enterprises

"The State should also ensure that it is supporting only those technical services which cannot be provided more effectively by other means, and which yield a real benefit to their customers, and thereby to the State itself. For this reason these activities must be accurately costed, justified, monitored and evaluated."

TIERNEY Report, page 101

For many firms it is not financially viable to maintain in-house expertise in a wide range of technical services such as analysis, testing, calibration, technical consultancy, training, information and advice. This Chapter examines the role of the State in the provision of scientific and technological services in support of the day-to-day operations of firms.

Decisions of the Government

- Forbairt will actively promote greater involvement of research organisations, universities and the RTC Technology Centres in the provision of S&T services to firms.
- Forbairt is directed to identify the full range of significant public and private sector activities aimed at assisting firms with the development of quality systems and to introduce, as early as possible, suitable arrangements for ensuring that these activities are effectively co-ordinated.
- Forbairt and other relevant organisations are directed to draw up business plans for their technical service activities, which should be reviewed in detail every three years.
- All Departments with responsibility for agencies providing technical services to clients should consider the putting in place of arrangements to allow agencies to retain a reasonable proportion of increased cost recovery above budget target, in order to improve the quality and range of their services.
- In the context of reviewing its future organisational requirements, Forbairt should address the need for 'new blood' in its technical services and for a long-term career development programme.
- All Government Departments with responsibility for laboratories should ensure that each of these undertakes a full analysis of the costs and benefits of accreditation by the National Accreditation Board and, on this basis, prepares an appropriate implementation plan.
- Each Government Department with responsibility for regulatory bodies should undertake a review of their current levels of service and the impacts which these are having on the innovation performance of firms, in consultation with firms and the Small Business Forum.
- An in-depth review of the optimum role, functions and location of the State Laboratory should be undertaken by the new STI Council and the Department of Finance.
- The Department of Enterprise and Employment and its agencies, notably the National Standards Authority of Ireland, should prepare a plan for increasing the level of participation, by firms, in the Technical Committees which formulate European Standards.

Introduction

The TIERNEY Report noted that most technical services required to support the development of firms, particularly in a smaller country dominated by small and micro firms, do not have a sufficient and consistent demand to be financially viable, and are therefore not attractive to private sector providers. Consequently, they must be provided by the State if the performance of industry is not to be significantly impaired. In Ireland, such technical support services are provided, to varying extents, by a range of public sector institutions, most notably Forbairt and Teagasc.

In its examination of the State system in the provision of scientific and technological services to firms, TIERNEY identified four areas of concern:

- the need to ensure that the full range of expertise within the relevant State institutions is utilised;
- the need for measures to facilitate access by firms to the service provider most appropriate to their needs;
- the need to ensure that these services are provided in a cost-effective manner;
- the need to ensure that the State's necessary regulatory activities are undertaken in a way which takes full cognisance of the development needs of firms.

Co-ordination and Utilisation of All Relevant Expertise

The TIERNEY Report called for an increased role in the provision of technical services to firms by State institutions whose main function is R&D, principally the Programmes in Advanced Technology (PATs), the National Microelectronics Research Centre (NMRC) and the Teagasc food research centres. Within these organisations there exists a wealth of expert knowledge and a range of specialist equipment which could make a significantly greater contribution to the solving of day-to-day production problems of companies, providing expert information and advice, and possibly catering for some of their specialised testing and analysis requirements.

The recently established Technology Centres Programme within the RTCs and DIT was seen as a very worthwhile initiative, with the potential to make their expertise much more readily available to firms. TIERNEY called for an early evaluation of this Programme to determine its effectiveness and its optimum future role within the National Innovation System.

At the same time, TIERNEY was concerned that the expanding range of public sector sources for technology services could lead to potential confusion for firms. The Report called for greater co-ordination, based around the Forbairt regional office structure, and an effective system of cross-referrals between the individual service providers. The following recommendations are particularly relevant:

- the company development operations of Forbairt, IDA Ireland and Shannon Development should make maximum use of the expertise within the PATs, NMRC and the Food Research Centres whenever appropriate;
- the third-level colleges and other State sector institutions should pay specific attention to identifying and assisting those firms which can benefit from currently available technology;
- the RTCs and DIT should become an integral

part of regional industrial development, and ensure that their specialist skills are more readily accessible to firms.

One area of particular concern was the variety of State services and support schemes with a role to play in raising quality competence in firms. TIERNEY considered that there is a need for improved co-ordination in this area, and for greater attention to smaller firms where the importance of quality is often poorly recognised.

The Government recognises that firms require a wide range of scientific and technical support services on a regular basis, in order to achieve cost-effective manufacture and enhanced quality. Even the largest companies cannot afford to be completely self-sufficient in every aspect of their technological needs. They will, from time to time, require specialised tests or a particular expertise where the maintenance of in-house capability is not an economically viable option. In these circumstances, the required services need to be readily available externally. For the much smaller firms which typify Irish indigenous industry, the resources devoted to quality and the range of in-company technical expertise or specialist equipment are very much less, and the need for external assistance is correspondingly greater.

The Government agrees with the recommendations aimed at ensuring that firms are directed efficiently to the most appropriate source of S&T services. It notes that the evaluation of the Technology Centres Programme was completed earlier this year and will be used by Forbairt to determine the future role of the Programme. As part of this process, Forbairt should establish an effective system of cross-referrals which should encompass, not only the Technology Centres, but also the universities and State sector organisations with a capability to provide technological assistance to firms.

Government Decisions

Forbairt will actively promote greater involvement of research organisations, universities and the RTC Technology Centres in the provision of S&T services to firms. This will include an effective system of cross-referrals at national and regional level, supported by the Forbairt Information System and their network of regional offices.

Forbairt will identify the full range of significant public and private sector activities aimed at assisting firms with the development of quality systems and introduce, as early as possible, suitable arrangements for ensuring that these activities are effectively co-ordinated.

Cost-effective Operation of State S&T Services

The TIERNEY Report recognised that, except where a significant niche market exists, the provision of technical services by State agencies would, in general, not be profitable. Whilst these activities will, therefore, require an on-going subsidy, TIERNEY wished to ensure that they operate in a fully business-like manner and that the State thereby receives maximum value for money. It made a number of recommendations which aim to achieve this effect, particularly the need for agencies to adopt a business planning approach to the provision of services and the

need for a greater incentive for agencies to improve performance.

The Report also expressed concern about the age profiles of the core technical staff in both Forbairt and Teagasc, which it recognised would continue to be the main providers of technological services. Some revitalisation of both agencies was considered necessary. Noting that Teagasc was initiating a 'new blood' recruitment programme, it called on Forbairt to do likewise.

The Government strongly endorses the need for S&T services to be provided within a "Business Plan" framework. Where a "developmental" element is required (i.e. where, in strict financial accounting terms, full costs are not recovered), this should be fully identified together with the underlying reasons, and the associated costs should be made fully visible. Such a transparent approach would facilitate the review and evaluation of these services.

The Government accepts that a more commercial approach to cost recovery in the State's provision of S&T services is inhibited by the general practice of reducing Exchequer support for services, pro-rata with increased cost recovery. In order to rectify this, there is a need for arrangements to allow agencies to retain a proportion of *increased* cost recovery above budget target, for the purpose of upgrading the quality and range of service provision.

The Government accepts the case for a 'new blood' recruitment policy for Forbairt technical services. In doing so, it recommends that this should be accompanied by a long-term career development programme, including continuous training, for the staff involved.

Government Decisions

Forbairt and other relevant organisations are directed to draw up business plans for technical service activities, which should be reviewed in detail every three years.

All Departments with responsibility for agencies providing technical services to clients should consider the putting in place of arrangements to allow agencies to retain a reasonable proportion of increased cost recovery above budget target, to allow the agencies to improve the quality and range of their services.

In the context of reviewing its future organisational requirements, Forbairt should address the need for 'new blood' in its technical services and for a long-term career development programme.

The Impact of Regulatory Activities

In considering the role of State S&T activities in relation to technical regulations and standards, TIERNEY identified four areas where action is required:

- the need for accreditation by public sector laboratories, to international standards;
- a review of the State's regulatory bodies in relation to their impact on the innovation and business development activities of firms;
- an examination of the role, functions and location of the State Laboratory;
- the need for active involvement of Irish manufacturers in the Technical Committees which formulate standards.

Laboratory Accreditation

The Government accepts the increasing need for new industrial products to be accompanied by

test, analysis or calibration by laboratories accredited to internationally accepted standards. In Ireland, many of the laboratories which issue test certificates are in the public sector. Certification by accredited laboratories is an essential requirement for many firms in order to break into and maintain markets at home and abroad. Consequently, the Government strongly endorses the recommendation that the various State-sector laboratories involved in the provision of analysis, testing and calibration services should quickly seek to achieve accreditation by the National Accreditation Board. It recognises, however, that significant costs are involved in upgrading to meet necessary standards. These should be quantified on a case-by-case basis and considered in the context of the national benefits which would ensue.

Government Decision

All Government Departments with responsibility for laboratories should ensure that each of these undertakes a full analysis of the costs and benefits of accreditation by the National Accreditation Board and, on this basis, prepares an appropriate implementation plan.

Regulatory Bodies

The Government recognises that the State's regulatory bodies can also impose major constraints on the innovative performance and general development of companies, if they cause undue delays in granting approvals. In agreeing with the call for these bodies to be reviewed, the Government has decided that each Department and State agency with a regulatory function should examine its own activities with regard to the effects on the innovation performance of industry.

Government Decision

Each Government Department with responsibility for regulatory bodies should undertake a review of their current levels of service and the impacts which these are having on the innovation performance of firms, in consultation with firms and the Small Business Forum.

State Laboratory

The Government accepts the view that the State Laboratory is a large organisation with considerable technical expertise, capable of contributing to the S&T objectives of several Departments and agencies. The Government, therefore, agrees that the optimum role, function and location of the State Laboratory be examined (including the issues covered in the submission by the State Laboratory in response to the TIERNEY Report).

Government Decision

An in-depth review of the optimum role, functions and location of the State Laboratory should be undertaken by the new STI Council and the Department of Finance.

Standards Formulation

With European Standards (ENs) increasingly used as the basis for public procurement within the Union, these Standards are becoming a major factor in the business of many firms. The

Government fully endorses the recommendation on this matter and considers that greater participation by Irish manufacturers in the Technical Committees which formulate these standards would lead to an early awareness of requirements, and thus give them a distinct competitive advantage.

Government Decision

The Department of Enterprise and Employment and its agencies, notably the National Standards Authority of Ireland, should prepare a plan for increasing the level of participation by firms in the Technical Committees which formulate European Standards.

A Case in Point – Improved Ceramic Flue Liners

The arrival of the 'open market' and the drive towards European-wide Product Standards offers both opportunities and threats to Irish manufacturers.

Ceramic flue liner manufacturers recently had to meet the threat posed by a new European Standard which had exacting specifications related to heat and acid resistance.

Technologists in the Ceramics Research Centre at Forbairt, working with a number of companies in the field – Flemings Fireclays in Athy, Irish Stoneware and Fireclays in Carrickmacross and Ulster Fireclays in Coalisland – and with some funding from the International Fund for Ireland, succeeded in developing a new materials formulation which could be used successfully in the existing plants to make a liner that met all the new specifications.

As a result, building specifiers for both the private and the public housing sector can continue to specify Irish manufactured liners.

A major import threat has been averted and jobs have been secured.

FAMOUS IRISH SCIENTISTS

Charles Parsons (1854-1931)

Ireland's most eminent engineer was the youngest son of William Parsons, the third Earl of Rosse, from Birr Castle in Co. Offaly. Charles Parsons invented the steam turbine engine in 1884, and this invention made dramatic contributions to electricity generation on land, and to transport at sea.

harles never went to school. Instead, he was educated by tutors at Birr. After his private schooling, Charles went to Trinity College Dublin, and then on to Cambridge University. A great need in the 1880s was for an engine which could drive a dynamo directly to generate electricity efficiently. High rotational speeds were necessary, and these were beyond the range of normal piston engines. Charles' breakthrough was to pass the steam through a series of bladed wheels, alternatively rotating and stationary. As it went through each pair, the steam expanded by a small amount, giving up some of its energy to rotate the shaft. In his first steam turbine of 1884, which incorporated several other brilliant innovations, he used 15 pairs of these wheels, and obtained an engine with a rotation speed of 18,000 revolutions per minute. He developed a dynamo to cope with this speed, and the age of the steam turbine was born. It was used first to light ships, as it was small and portable, but then was developed for use in power stations.

Realising its potential for marine propulsion, Charles built a small experimental boat, the Turbinia, and in her tried out different engines and propellers. By 1897, he had a vessel which could travel at an unheard of 34 knots. Having trouble convincing a conservative British Navy of its importance, he hit on an audacious sales pitch. Uninvited, he joined the Naval review organised to celebrate the Diamond Jubilee of Queen Victoria. The Turbinia could not be caught as it careered amidst Her Majesty's Ships. It worked, and before long his turbine was commissioned for all British warships, and for merchant ships too.

Support for Natural Resource-based Sectors

"In order to develop their full potential the natural resource sectors need basic and applied research, together with extension and general technological services, which are applied not just to the manufacturing and processing areas, but also to the services sector."

TIERNEY Report, page 103

Previous Chapters concentrated on broad industrial and economic development issues. Ireland's environmental, agricultural, forestry and marine resources are among its major assets. This Chapter focuses on our natural resources, and particularly the S&T activities which are required in order to maximise their economic potential.

Decisions of the Government

- The Government agrees that the National Sustainable Development Strategy being prepared by the Minister for the Environment will take into account the relevant TIERNEY recommendations.
- The Government has instructed the Department of Agriculture, Food and Forestry and Teagasc to examine the feasibility and operational requirements needed to raise the level of contributions from the farming community for agricultural research. The Department of Agriculture, Food and Forestry will also examine how the Committee for Agricultural Research might be developed to provide a more open system for supporting R&D in this sector.
- The Government endorses the view that the Food Research Centres in Teagasc and the third-level sector should ensure that they have a clear mission statements, accompanied by measurable objectives covering both their research and technology transfer activities. The Department of Agriculture, Food and Forestry will ensure that in-depth evaluations of these centres are carried out.
- In the current year, the Department of the Marine has provided increased funding for marine research (£5.07 million in 1996, compared with £4.6 million in 1995). The case for increased resources will be examined under the proposed structures for co-ordinating and prioritising S&T expenditure. The Government endorses the need for maximum co-ordination between that Department and the Department of Agriculture, Food and Forestry on the allocation of funds for research on marine-based foods.
- The Government endorses the view that the Department of Agriculture, Food and Forestry should arrange a review of all aspects of forestry research and technological development. This review should cover the effectiveness of the current programme, the level and sources of funding for the future, the priorities and administrative structures for allocating these funds and the optimum means for enhancing the rate of development of firms in the sector.
- The Government accepts that there are other niche sectors based on natural resources with potential for high export earnings, such as the equine industry, and has decided that the S&T needs of such sectors be examined under the auspices of the new STI Council.
- The Government accepts the need for an integrated approach to the general and technological development of firms in natural resource-based sectors. It has decided that such an approach should be co-ordinated through Forbairt.

Introduction

The TIERNEY Report noted that Ireland possesses major assets in terms of its environmental, agricultural, marine and forestry resources. It considered that, with the exception of agriculture, their potential role in the national economy had not been adequately recognised in the past. As a result, there is now an urgent need for appropriate S&T initiatives to realise the full benefits to the country which these assets could provide. In this context, TIERNEY made a series of recommendations based around three main themes:

- the need for a unified approach to management of the environment, with a coherent programme of supporting research;
- the achievement of increased levels of research and development in a number of priority areas in the marine and forestry-based sectors, with a strong focus on achieving a high level of added value;
- the undertaking of a major effort, to be co-ordinated through Forbairt, to develop natural resource-based firms, many of which are very small.

Research in Support of Environmental Management

TIERNEY expressed concern that several different Departments and agencies have responsibility for various aspects of the environment. As a result, a unified national plan for managing this key asset is absent, as is a properly funded and structured research programme to support such a plan. TIERNEY made a series of recommendations to address these deficiencies.

The Government notes that the high quality of the natural environment in Ireland and, in many cases, of the built environment, provides a powerful foundation for product development in a number of areas. As a result of having relatively little in the way of heavy industry, Ireland has largely avoided the pollution problems encountered by many of our main competitors. This clean, green image is a major asset. It is a key factor in attracting tourists to the country, and in the acceptability of our agricultural and food products in overseas markets. The Government recognises that the principle of "sustainable development" is of immense importance in securing the foreign earning potential of both sectors. An attractive environment has become a key factor in promoting knowledge-based high value-added projects in Ireland, with a demand for qualified employees.

Government Decision

In the light of these considerations the Government supports the recommendation to put in place a national environmental plan and supporting S&T programme. It notes that work on various aspects of these matters is underway with the support of the Environmental Protection Agency (EPA), which published a discussion document on environmental research, the Joint Oireachtas Committee on Sustainable Development, and particularly the Minister for the Environment who is currently preparing a National Sustainable Development Strategy. This Strategy will take into account the relevant TIERNEY recommendations.

Agricultural Research

TIERNEY considered that Ireland's current level of expenditure on R&D for agricultural produc-

tion was unduly low, both in comparison to other EU countries and in relation to its major importance for our national economy. It called for this to be raised, with the additional funding coming from an increase in the voluntary contributions from the producers. The TIERNEY Report also called for the establishment of a committee to set research priorities and ensure co-ordination between Teagasc and the third-level sector. It also recommended that the food research centres within Teagasc and the third-level sector should operate under a remit similar to the Programmes in Advanced Technology (PATS) - see Chapter 10 - particularly in relation to maximising their technology transfer activities, and should be evaluated against the same criteria.

In the agricultural area, the Government accepts that Ireland has a production capacity considerably exceeding our internal needs. It is, therefore, important to ensure that the foreign earnings potential of the sector is maximised. The TIERNEY recommendation for an increase in the level of agricultural research is, therefore, supported by the Government. In relation to funding, it agrees with the concept that the direct beneficiaries of agricultural R&D, namely the farming community, should be the main source of the additional finance required.

In relation to the management of the research, particularly the selection of relevant projects, the Government notes that the vast bulk of current funding is administered through Teagasc, and almost all of this is used to support research activities within their own centres. The Minister for Agriculture has established a Committee for Agricultural Research to set priorities for the spending of a small new stimulus fund provided under EU Structural Funds.

The Government agrees with the objective of the TIERNEY recommendation on the role of a committee to prioritise agricultural research spending (mirroring the system which was established for food research). The Department of Agriculture, Food and Forestry will discuss with Teagasc how this could be developed to provide a more open system with greater involvement of the third-level sector.

In relation to food research, the Government endorses the recommendation that the centres involved should operate in a similar manner to the PATs, and should undergo corresponding in-depth evaluations against the same type of criteria.

Government Decisions

The Government has instructed the Department of Agriculture, Food and Forestry and Teagasc to examine the feasibility and operational requirements needed to raise the level of contributions from the farming community for agricultural research. The Department of Agriculture, Food and Forestry will also examine how the Committee for Agricultural Research might be developed to provide a more open system for supporting R&D in this sector.

The Government endorses the view that the Food Research Centres in Teagasc and the third-level sector should ensure that they have clear mission statements, accompanied by measurable objectives covering both their research and technology transfer activities. The Department of Agriculture,

Food and Forestry will ensure that in-depth evaluations of these centres are carried out.

R&D in the Marine and Forestry Sectors

TIERNEY also considered that the level of technological activity in both the marine and forestry sectors was inadequate, bearing in mind the significant development potential of these sectors. It made a series of recommendations in relation to both increased funding and the mechanisms for overseeing S&T activities in each of these sectors. In welcoming the major increase in finance for food research which had been introduced under the current Structural Funds Programme, the Report called for part of it to be devoted to research on marine-based foods.

The Government agrees that the marine sector is another area of significant potential and notes the TIERNEY observation that Ireland's seabed area is the third largest in the European Union in terms of area, and by far the largest in relation to population. It, therefore, represents a key asset which has, so far, failed to deliver significant economic benefit.

The Government endorses the need for maximum co-ordination between the Department of the Marine and the Department of Agriculture, Food and Forestry on the allocation of funds for reasearch on marine-based foods.

Ireland's forestry sector is likewise a natural resource area with good economic and regional development potential. A major planting and replanting programme has been developed by the Government in recent times. As a result, increasing amounts of native timber will become available in the coming years. The Government accepts that Ireland's wood products industry is underdeveloped, with the consequent risk that it will be unable to capitalise fully on this advantage.

The TIERNEY recommendations on the need for increased funding of both marine and forestry-related research are noted by the Government. The case for increased resources will be examined under the proposed structures for co-ordinating and prioritising S&T expenditures. It also agrees that any additional funding should be mainly used to support projects with a strong added-value focus.

The Government also endorses the call for a review of the forestry R&D programme and agrees that this should include an examination of the status of COFORD, the National Council for Forest Research and Development.

Government Decisions

In the current year, the Department of the Marine has provided increased funding for marine research (£5.07 million in 1996, compared with £4.6 million in 1995). The case for increased resources will be examined under the proposed structures for co-ordinating and prioritising S&T expenditure. The Government endorses the need for maximum co-ordination between that Department and the Department of Agriculture, Food and Forestry on the allocation of funds for research on marine-based foods.

The Government endorses the view that the Department of Agriculture, Food and Forestry should arrange a review embracing all aspects of forestry research and technological development. This review should cover the effectiveness of the current

programme, the level and sources of funding for the future, the priorities and administrative structures for allocating these funds and the optimum means for enhancing the rate of development of firms in the sector.

R&D in other Niche Sectors based on Natural Resources

The TIERNEY Report recognised that there are other natural resource-based sectors, such as the equine industry, with significant contributions to make to the national economy. It noted that the research and technological needs of such sectors have not been fully recognised in the past, and recommended that this deficiency be addressed by the proposed new STI Council.

Government Decision

The Government accepts that there are other niche sectors based on natural resources with potential for high export earnings, such as the equine industry, and has decided that the S&T needs of such sectors be examined under the auspices of the new STI Council.

Development of Natural Resource-based Firms

The TIERNEY Report noted that many of the firms in the natural resource-based sectors, particularly marine and forestry, are very small and have low levels of technological competence. In order to maximise the potential economic benefits from these sectors, these developmental constraints need to be addressed. This requires an integrated approach, with the necessary technological assistance being provided by the relevant S&T programme and Forbairt being responsible for other developmental aspects and providing the co-ordinating and management functions. TIERNEY noted that this type of co-operative programme is already being developed by Teagasc and Forbairt for firms in the food sector, and recommended that it be mirrored in the other natural resource-based sectors.

Government Decision

The Government accepts the need for an integrated approach to the general and technological development of firms in natural resource-based sectors. It has decided that such an approach should be co-ordinated through Forbairt.

A Case in Point: Food Safety

In the food sector – more than any other – consumer confidence is a critical factor.

In Ireland, Europe and elsewhere, consumer attitudes and preferences have become more sophisticated and, more and more, are a determining factor in achieving market success. As consumers demand assurances on the purity and safety of the food they eat, Irish food must trade on the strength of its high quality.

The Teagasc National Food Centre, in collaboration with UCD, UCC and UCG, is carrying out research to establish the levels of chemical residues in food, to develop more rapid and cheaper methods of detecting residues and pathogens and to develop procedures for food processing which minimise the risk of food contamination. Bringing our best researchers together in this project is designed to assure consumers that the product is safe, wholesome and of the highest quality.

HOW SCIENCE RESEARCH AND TECHNOLOGY HAS IMPACTED ON MY LIFE AND WORK

Fergal Quinn, Superquinn

I have always looked on technology, not as a way of threatening jobs, but as a way of extending people's reach in their ability to serve customers' real needs. Meeting customer needs is the dynamic for growth in any business.

For instance, using band saws to cut meat carcasses into quarters was seen by some as a means of employing fewer butchers. However, I saw it as an opportunity to use butchers better. Now our butchers spend almost as much time advising customers how to cook meat to best advantage as they do in preparing the meat itself for sale.

Technology has freed them to devote more attention to meeting the needs of customers – to the benefit of the customers, the butchers themselves, and the bottom line of our business.

Meanwhile, and just to stick to the area of meat, we have found that systematic scientific research can be harnessed to provide benefits to customers even in areas as subjective as taste. Tenderness is the critical quality dimension in beef, and research showed us that tenderness could be enhanced by paying attention to factors that traditionally had not been considered relevant.

As an example, research established for us that, in hanging meat, tenderness is determined not only by the length of time it is hung, but also by the manner in which it is hung.

Retailing is a business with tremendous scope for the use of technology. But side by side with the arrival of new technology has grown the demand for better, more individualised customer service.

So, no longer do checkout operators have to concentrate on remembering literally hundreds of prices, changing every week. Scanning looks after that side of the operation, and the checkout operator can focus on the task of helping the customer. Someday, perhaps, checkouts will disappear altogether – freeing up our resources to give more attention to meeting customer needs elsewhere in the shop.

Technology today is offering us the opportunity to control our stocks better, so that fewer customers are irritated by finding what they want is out of stock. Technology is giving us the means to reward the most loyal of our customers, and increasingly to cater for their needs in a more individual way.

In our business, the competitive battle ground of tomorrow is the quality of customer service that we can deliver. Paradoxically, that quality can only be delivered by people – machines can never satisfy a customer the way a person can. But technology can extend the ability of people to reach excellence in meeting customer needs. I see technology being used more and more to achieve that trend across the whole range of service businesses.

Programmes in Advanced Technology

"The overall aim has been to devise a system which will maximise the contribution to industrial development in Ireland, in both the short and long term, based around top quality researchers undertaking projects of scientific excellence and industrial relevance. A key role for these researchers will be maintaining awareness of worldwide developments in their technologies, identifying and 'localising' those which have the greatest potential relevance to Ireland."

TIERNEY Report, page 89

Certain enabling technologies will have a pervasive impact on economic and industrial development. This Chapter examines the role and optimum structure for State-funded research programmes in key technologies so as to ensure effective transfer of expertise to the business sector.

Decisions of the Government

- **The Programmes in Advanced Technology (PATs) will be established as a company. The company, which will implement policy and strategy laid down by the Minister, will be formed as a subsidiary of Forbairt, in consultation with the Minister for Commerce, Science and Technology. The Minister will also establish a standing Board to address PATs policy and strategy and annual funding decisions for the individual PATs, to prioritise between them – including closure of PATs and establishing new ones – and to advise the Minister accordingly. The Board will be representative of third-level, industry, and State interests in the PATs.**
- **The funding allocation to the NMRC should be treated within the same funding process and on the same policy basis as the other programmes. However, further detailed examination of the considerable legal, financial and other aspects is required before effect could be given to the structural changes proposed.**

Introduction

A number of programmes involving research and technology transfer in advanced technologies represent a very significant element of public investment in the science, technology and innovation (STI) base in Ireland. Seven programmes – BioResearch Ireland (BRI), Advanced Manufacturing Technology (AMT), Optronics Ireland, Materials Ireland, PEI Technologies, Teltec Ireland and Software – constitute the conventional Programmes in Advanced Technology (PATs). They range in age from 4 to 9 years and employ over 500 people – including over 200 post-graduates. Their expenditure budget for 1996 is almost £20m., over £11m. of which comes from income earned for specific project work, with the balance of £8.6m. coming from the State (75% of which is funded by EU Structural Funds). The work of the PATs is undertaken in 36 separate centres located almost exclusively on third-level campuses. A review of the PATs was carried out by the Office of Science and Technology in 1991/92. A Policy Statement was issued by the then Minister for Science and Technology which endorsed the goal of the PATs as being "to enhance the performance of industry in Ireland through research and technology transfer activities".

Operationally, the PATs are funded by the Office of Science and Technology and managed by Forbairt. The Software PAT is a slightly different model to the other PATs. While it is managed by the National Software Directorate within Forbairt, the centres located in the col-

leges are established as separate companies.

The National Microelectronics Research Centre, based at UCC, was established in 1981 to provide a silicon wafer fabrication laboratory which would make available R&D and specialised training facilities for the semi-conductor fabrication industry. At present, the NMRC employs some 200 people and has an expenditure of over £7m, made up of direct State subvention, grants from UCC, international research contracts, commercial research contracts at home and abroad and grants through national research programmes.

TIERNEY Report

The TIERNEY Report examined the Programmes in Advanced Technology at some length because they represent such a substantial resource. TIERNEY recognised the potential role they could play in developing third-level research capability and delivering key technologies to firms in Ireland. The PATs are also a focal point for the attraction of overseas investment in high technology areas and have the potential to lead to the establishment of new industries based on start-up companies.

TIERNEY believed that the key component of the PAT concept was the productive partnership between industry, the third-level sector and the industrial development area of the State sector, represented by OST, the Department of Enterprise and Employment and its agencies.

TIERNEY considered that the PATs had been largely successful to date, but that their impact and effectiveness could be further enhanced by reducing some operational constraints and increasing their focus on assisting the development of companies operating in Ireland, particularly indigenous firms. It gave extensive consideration to a variety of revised structures which might achieve these aims. It was very conscious of the vital role played by the host universities and of the need to maintain their enthusiastic commitment, but it argued the need also for a sufficiently clear distinction between the operations of PATs and those of the associated academic departments.

The TIERNEY Report felt that the type of structure best suited to the needs and nature of the PATs was one which would ensure complete openness, accountability and transparency on the one hand, and the necessary legal basis for developing and exploiting research opportunities on the other. The TIERNEY approach was based on two essential needs. An independent legal entity is required, which would enable the PATs to enter contracts and be obliged to produce clear accounts. An independent legal entity could also operate with sufficient flexibility in terms of staffing, marketing and financial independence to achieve its objectives (particularly its commercial targets). Secondly, it is essential to recognise that the support of indigenous industry development is only one objective of PATs. They are also required to develop university research capability, track emerging technological developments, develop university/industry collaboration, develop intellectual property rights and exploit these through commercialisation. They are expected to train postgraduates in industrially-relevant research, contribute to the attraction of multinationals to Ireland and improve Ireland's participation in international programmes.

The TIERNEY Report recommended:

- The PATs, including Software and the NMRC, should be incorporated into an independent legal entity. This company should have its own Board and all the necessary legal rights;
- PATs should ensure a clear independence from the academic departments; there should be an appropriate arrangement between them for the use of resources;
- Key PAT employees should have industry-style employment contracts.

Government Consideration

The Government notes the conclusion of the TIERNEY Report that the PAT concept has been largely successful. It endorses the need to develop a number of strong centres of expertise in technologies of strategic importance to the development of the Irish economy, to build on the most obvious source of such expertise in the third-level sector and to establish effective ways in which that competence and expertise is made available to Irish industry. The Government emphasises that this is particularly necessary in relation to Irish-owned industry, which suffers most from a weakness in technological capability. However, it is also important for the PATs to develop strong links with foreign-owned industry in Ireland and with international research opportunities, in order:

(i) to develop the knowledge-base, expertise and research capability in Ireland and to help upgrade the technological capability and competitiveness of Irish-owned industry;

(ii) to better support and exploit the fee-earning capacity of the PATs

The Government notes the significant differences in the origins, dates of establishment, stages of development, levels of performance, client bases and institutional structures of individual PATs and the NMRC. It accepts that there are also significant differences in the extent to which these bodies individually are in a position to develop advanced technologies and related skills of relevance to Irish industry and, at the same time, supply fee-earning services to firms. A balance between these two objectives is necessary and this balance will vary between programmes.

The Government concludes that there should be a common policy approach to the programmes and that their funding should be administered within a common funding envelope established by the Department of Enterprise and Employment. There should also be a consistency of approach in relation to the formulation of objectives, measurement of results, accounting procedures, evaluation of performance and establishment of priorities across the different programmes. However, flexibility is needed in relation to the management structure adopted for individual programmes to reflect the stage of development, client-base and level of self-financing of each body and to ensure that the sense of innovation, intellectual exploration and commercial application, which is the hallmark of a successful applied research organisation, is not stifled.

The Government concludes that the overall scale of activity, the significant level of public funding, the objectives and future potential of the PATs and related bodies require that they be planned and administered in a thoroughly professional and dynamic manner. It notes that the present structures have grown in an ad-hoc manner, over a number of years, and have given rise

to inconsistencies in approach and objectives. A more solid legal base and management structure is needed in order to facilitate:

- setting targets, their realisation and monitoring;
- the establishment of a more rational basis for the allocation of funds between the different programmes;
- the reallocation of funds to reflect performance and policy priorities;
- the establishment of new or replacement programmes where necessary.

A critical element of the structure is to reflect and to facilitate, in a more formal way, the partnership between the three pillars on which the programmes have been successfully built to date – the universities, industry and the State. In order to maintain that essential partnership, each particular interest should be allowed to participate equally in any new structures established to manage the overall programmes.

The Government considered the TIERNEY recommendation that a company be established as a separate, stand-alone entity. In essence, this would represent the establishment of an additional State agency with an industrial development remit. The Government considers that there are strong and convincing arguments against increasing the number of State agencies with such a remit. By establishing the company as a subsidiary of Forbairt, this difficulty would be avoided. More importantly, consideration of the special development needs of Irish-owned industry, would be assured. At the same time, an appropriate balance of representation on the Board, would ensure that the necessary and strong links between the PATs and multinational companies can be maintained and developed.

In relation to other TIERNEY recommendations, the Government is of the view that, while there should be a transparent arrangement between academic departments and PAT Centres, such arrangements should be developed in a way which maintains good working relationships and which ensures the maximum of research is performed for the funding provided. The Government supports the recommendation that employment contracts for PAT staff should be designed flexibly to motivate and reward staff. This would be a matter to be dealt with by the new PAT company.

Government Decision

The Government considers that the PATs are a strategic public policy spending programme and should remain under the policy direction of the Minister for Commerce, Science and Technology. The Government confirms the current Ministerial Policy Statement, in particular the fact that Exchequer funding of the programmes will be made available for strategic research on a competitive basis. The Government accepts that, because of the varied objectives of the PATs, they must be governed in a way which respects the contribution and objectives of the different partners involved and they must be managed with the necessary vision and dynamism to achieve those objectives. The Government believes that, taking account of these considerations, the PATs should be managed by Forbairt on a contract basis, separate from its mainstream activities.

In that context, the Programmes in

Advanced Technology (PATs) will be established as a company. The company, which will implement policy and strategy laid down by the Minister, will be formed as a subsidiary of Forbairt, in consultation with the Minister for Commerce, Science and Technology. The Minister will also establish a standing Board to address PATs policy and strategy and annual funding decisions for the individual PATs, to prioritise between them – including closure of PATs and establishing new ones – and to advise the Minister accordingly. The Board will be representative of third-level, industry, and State interests in the PATs.

National Microelectronics Research Centre (NMRC)

In considering the TIERNEY recommendations in relation to the NMRC, the Government took account of a number of factors:

- The establishment of the NMRC predated the other PATs. The genesis of the NMRC goes back more than 20 years to research work carried on at University College Cork, which led to the Government decision in 1981 to support a national microelectronics facility.
- Since its establishment, the NMRC has evolved to become a significant element of the technological infrastructure which helps to attract to Ireland internationally mobile investment in the electronics industry (the fastest growing output, export and employment sector in Ireland). It also provides support for Irish-owned electronics firms, but of a lesser order.
- At present, the NMRC has employment of some 200 and expenditure of over £7m.

Government Decision

The funding allocation to the NMRC should be treated within the same funding process and on the same policy basis as the other programmes. However, further detailed examination of the considerable legal, financial and other aspects is required before effect could be given to the structural changes proposed.

A Case in Point – BioResearch Ireland-Diagnostic Kits for Osteoporosis

Osteoporosis is already a major healthcare problem. Characterised by a loss of bone density, it often leads to fractures of the hip, spine and wrist.

The work being done by the PATs, in taking innovative research ideas from the university laboratory to the business sector and, ultimately, the marketplace is well illustrated by the activities of BioResearch Ireland in the field of Osteoporosis.

Early diagnosis of bone loss can help clinicians to treat the condition. One approach to diagnosis was pursued at UCG where a test for Osteocalcin was developed by Professor Patrick Fottrell. This test was taken on by BioResearch Ireland and further developed into a diagnostic kit (a product containing all the components and reagents needed by hospital laboratories to perform diagnostic tests).

The product is now one of the major assays used in the diagnosis of Osteoporosis in hospitals and clinics in Ireland and has been successfully marketed throughout Europe and in Japan.

BioResearch Ireland has recently licensed

its Osteocalcin immunoassay to an Irish biotechnology company – Trinity Biotech PLC. The availability of new drugs to treat Osteoporosis has stimulated great interest in the diagnostic tools used to diagnose and monitor the condition and the product promises to be a major success for this growing Irish biotechnology company.

FAMOUS IRISH SCIENTISTS

Harry Ferguson (1884-1960)

Agriculture has been, and remains, a vitally important industry in Ireland. It is appropriate then that it is an Irish engineer who is credited with revolutionising not only Irish but World agriculture. Harry Ferguson didn't invent the tractor, but he dramatically changed its design, and the way it is used with accessories.

Harry was born at Growell, near Hillsborough, in Co. Down, the fourth son in a family of eleven. He left school at 14 to work on his father's farm, but soon became an apprentice to his brother's car and cycle repair business. While there, he became involved in motor cycle and car racing, and fortunately lived to tell the tale. He was the first man in Ireland to design and build his own aeroplane, which he flew on December 31, 1909.

He had set up his own garage business in 1911, and in 1914 he began to sell American tractors. These were heavy, difficult to adjust and dangerous. If an attached plough hit an obstacle, the front end of the tractor was likely to rise up, often with fatal results. Harry designed and built a new style plough, noted for its simplicity and lightness, but most of all for a brilliant innovation. The plough was coupled to the tractor in a three point linkage, so that tractor and plough formed a single unit. He patented the "Ferguson System" in 1926. The plough had no wheels of its own, and the coupling transferred the weight, so that, when an obstacle was encountered, the front end did not rise, and the plough could be raised easily using a lever beside the driver. He later added an hydraulic system.

In 1938, he agreed a deal with Henry Ford, to sell a tractor of Harry's own design. Henry Ford became the richest man in the world through mass producing cars. By 1947, 300,000 Ford Ferguson tractors had been built.

Harry's company later merged with a large Canadian Company, Massey-Harris, to form Massey-Ferguson, which continues to supply tractors and agricultural machinery world wide.

A full-scale replica of Harry's aeroplane, and an early tractor and plough, are on display at the Ulster Folk and Transport Museum at Cultra, Co. Down.

Third Level Research and the Role of the Colleges

"The flow of information between elements of the knowledge base, particularly flows into industry, must increase. Only in this way can Ireland benefit from its considerable investment in capital and human resources."

TIERNEY Report, page 115

As well as direct industry/college linkages, third-level research also plays a wider role in the innovation system. This Chapter examines the TIERNEY recommendations in relation to the level and funding of research in the universities and the RTCs/DIT and suggestions for increasing the interaction between the third-level colleges and industry.

Decisions of the Government

- The Government endorses the recommendation to provide additional funding for basic and strategic research in 1996 and beyond, and will do so as resources permit. In 1996, the Department of Enterprise and Employment allocated £3.2 million, an increase of £1.7 million on the 1994 allocation to these activities.
- The Department of Health has provided extra funding for health research in 1996, increasing the grant to the Health Research Board from £2.3 million in 1995 to £2.74 million. Further increases will be considered as resources permit.
- In 1996, the Department of Enterprise and Employment doubled the annual PhD research scholarship grant to £2,000. The Government has instructed the Department of Education and the Department of Enterprise and Employment to work on proposals for the future funding of doctoral students.
- The Department of Enterprise and Employment has launched a scheme of post-doctoral grants in 1996, in recognition of our EU Presidency year, at a rate of £20,000 per annum for two years. The Department of Education will also introduce a scheme of post-doctoral fellowships. The Government has instructed Forfás to assist in co-ordinating the work of various Departments and agencies which support post-doctoral students.
- The Government accepts the need to continually update research equipment in the third-level sector. The Government has instructed the Department of Education and the Department of Enterprise and Employment to liaise in an examination of the issue. Funding will be considered in the context of Government decisions on the annual Estimates.
- The Department of Enterprise and Employment has allocated £200,000 in 1996 for new international research collaboration projects.
- Forbairt will consult with local university research strengths and with the Regional Technical Colleges/Dublin Institute of Technology in the preparation of its regional development plans and encourage their involvement in developing innovation capability among companies at regional level.
- Each third-level college should publish a policy statement in relation to its research activities ("Research Charter"). The Department of Enterprise and Employment and the Department of Education will be involved in the discussions on the research charter with the colleges.
- The Department of Education and the Department of Enterprise and Employment

will explore, in consultation with the third-level institutions, how best to maximise technology transfer out of colleges.

- Forbairt's Intellectual Property Unit will actively promote the development and exploitation of intellectual property among academics and researchers.
- The Minister for Commerce, Science and Technology will promote a model contract relating to joint industry-college research work, particularly addressing the question of intellectual property rights. Discussions on the issue have taken place between the Industry Research and Development Group and the colleges.
- The Government has instructed the Department of Education and the Department of Enterprise and Employment to discuss with the universities how to extend their use of in-course industrial placements.

Research in Third-Level Colleges

Introduction

Academic research is recognised as an important component of the national system of innovation in all countries. Three key aspects of the activity are increasingly highlighted:

- its role in generating new knowledge and in providing access to knowledge generated in other countries;
- its role in educating and training the next generation of researchers and technologists for work mainly in academia and in industry;
- the increasing relevance of academic research for industrial development.

Research and development has traditionally been viewed as a continuum, ranging from basic (or intellectually-driven fundamental research) at one end, to product development in industry at the other. This distinction has always been somewhat artificial and it is rapidly disappearing in modern high-technology sectors where the time interval from original discovery to commercial exploitation is constantly reducing.

Basic and Strategic Research

The TIERNEY Report emphasised that basic research is an important element in the economic development process, providing in an interactive fashion, the theoretical groundwork for more applied research and development leading to industrial innovation. Certain sectors (e.g. chemicals) depend on basic research for product innovation, whether performed internally or in collaboration with the third-level sector. It is also an essential component for training new researchers and for enabling as many as possible of these young researchers to remain in Ireland while completing their post-graduate or doctoral studies. The rapid growth, over the last decade, of high-technology industry in Ireland (electronics, computers, pharmaceuticals) has been facilitated by an increased output of engineers and scientists. Further expansion, and increased commitment and roots, particularly by the multinational companies in these sectors, requires the production of highly-trained researchers to add

value to existing manufacturing activities by enabling more research and product development to take place locally.

TIERNEY used internationally comparable data to demonstrate that the level of basic research in Ireland is unusually low (close to 10% of the average level for the EU States). Furthermore, there is very little in the way of discretionary funding for specific basic research projects. Many countries have Research Councils for various fields of science (engineering, medicine, chemistry, etc.) whose main function is to select and fund worthwhile research projects in the third-level sector and research institutes.

The TIERNEY Report recommended a phased increase in the level of basic research funding, rising from £1.5m at present to £6m per year within five years. Funding for strategic research (which is basic research with a more focused orientation) should be increased at the same time.

The Government accepts that the funding for basic research should move towards £6m per annum as resources permit and that support for strategic research should also be increased. It believes that the funding should be allocated under a set of clear principles and criteria. These should include excellence, relevance to national economic development and performance measurement, leading to prioritisation of research projects. The recent establishment of the National Research Support Fund Board, to oversee the allocation and spending of research funds, is a positive step in this direction.

Health Research

TIERNEY argued also that, despite the support provided from non-State sources, medical research is under-funded in Ireland, resulting in failure to incorporate medical advances into our healthcare system, loss of researchers to other activities and loss of profile for Irish medical research in terms of attracting mobile healthcare industries. It recommended that funding for health research, supported by the Health Research Board, should double to £5m per year.

Government Decisions

The Government endorses the recommendation to provide additional funding for basic and strategic research in 1996 and beyond and will do so as resources permit. The Department of Enterprise and Employment has increased the annual level of funding for basic research from £1m in 1994, to £1.5m in 1995 and £2m in 1996. Strategic research funds have likewise been increased over the same period from £0.5m to £1m and £1.2m respectively.

The Department of Health has provided extra funding for health research in 1996, increasing the grant to the Health Research Board from £2.3 million in 1995 to £2.74 million. Further increases will be considered as resources permit.

Funding of Post-Graduate Students

The TIERNEY Report found that support for doctoral and post-doctoral students is unsatisfactory. At present, there is reasonable support for those students working in the Programmes in Advanced Technology – a minimum of £3,000 per year, as well as through a variety of others schemes funded by different Departments. For

those not supported through the more specific programmes, the Office of Science and Technology has provided a minimum level of assistance (£1,000 per year for a three-year period) for the top 160 students. The TIERNEY Report recommended that all PhD students in science and technology areas should be funded at a level of not less than £3,000 per year. It also recommended that a system of post-doctoral fellowships should be introduced.

TIERNEY discussed the appropriateness of the number and type of post-graduates being produced, particularly doctoral candidates. It believed that ways should be considered to ensure that sufficient numbers of doctorates are being provided in areas of national importance.

The Government is conscious that PhD students are financed through a variety of schemes operated by different Government Departments and accepts that this situation needs to be rationalised and consolidated. A clear picture is needed of the minimum numbers required in the relevant disciplines and, where gaps are identified, they will need to be addressed.

Government Decisions

In 1996, the Department of Enterprise and Employment doubled the annual PhD research scholarship grant to £2,000. The Government has instructed the Department of Education and the Department of Enterprise and Employment to work on proposals for the future funding of doctoral students.

The Department of Enterprise and Employment has launched a scheme of post-doctoral grants in 1996, in recognition of our EU Presidency year, at a rate of £20,000 per annum for two years. The Department of Education will also introduce a scheme of post-doctoral fellowships which will enable the creation of five fellowships commencing in the academic year 1996-1997. The Government has instructed Forfás to assist in co-ordinating the work of the various Departments and agencies which support post-doctoral students and in bringing consistency to this area.

Equipment for Research

Modern research relies heavily on access to equipment. University equipment has historically been funded by a capital grant from the Higher Education Authority (HEA) but the level of this grant has remained at £2m for the past ten years, to cover all seven institutions. The OST has also funded equipment in the universities and technical colleges, through a variety of schemes which support basic, strategic and applied research as well as through the Programmes in Advanced Technology. Other sources of funding, from national and international research contracts mainly, have also made a contribution towards equipment, but increasingly these contracts support only current spending. The overall result has been a gradual obsolescence of university equipment. The HEA has estimated this shortfall at £3-4m per year, or perhaps £50m in total.

With the introduction of new legislation in 1992, the Regional Technical Colleges / Dublin Institute of Technology have been freed to play a much stronger role in research and

regional industrial development. Applied research projects between these colleges and enterprises are increasing significantly. Access to up-to-date equipment is essential, not only to enable such contract research to continue but also to guarantee the output of high-quality technologists which industry needs.

The TIERNEY Report recommended the setting up of a new fund to provide an additional £5m per year for equipment in the third-level sector.

The Government accepts the need to continually update research equipment in the third-level sector. There is a need for further information on and examination of the amount and sources of funding for such equipment outside the regular Department of Education / HEA allocations, and for better co-ordination in this whole area.

Government Decision

The Government accepts the need to continually update research equipment in the third-level sector. The Government has instructed the Department of Education and the Department of Enterprise and Employment to liaise in an examination of the issue. Funding will be considered in the context of Government decisions on the annual Estimates.

International Collaboration

TIERNEY recognised the importance to researchers of international collaboration and interaction with overseas colleagues as a means of keeping Irish research in touch with international standards and as a source of knowledge transfer to Ireland. The EU Framework Programme has helped this process considerably but is, to some extent, driven by the needs of the bigger countries.

The TIERNEY Report recommended an annual allocation of £200,000 to encourage bilateral collaborative initiatives of interest to Irish researchers. It also considered that the question of Irish participation in "megascience" projects such as CERN – the European Centre for Nuclear Research – should be reviewed.

The Government accepts the value of better international collaboration, both at academic and industry level. As a small country, Ireland does not have the resources it would like for this purpose and, therefore, has to be selective. The Government is conscious that the EU Framework Programme, with major financial resources, has contributed to the development of a huge network across Europe in which Irish researchers have enjoyed considerable success. The aim of Ireland's membership of the European Space Agency (ESA) is to foster the development of indigenous industry through participation in highly advanced R&D programmes, leading to high technology transfer and product commercialisation. Other European bodies, such as COST (Co-operation in Science and Technology), provide for joint projects involving collaboration with researchers in Eastern Europe. There is a need, also, for example, to make better use of our membership of EUREKA, a Europe-wide network for collaborative R&D by industry.

The Government also wishes to promote niche opportunities for researchers, whether academic or industrial, which will best utilise the

limited funding available. Funding should be used for additional activities which promote greater collaboration between Irish researchers and/or Irish industrialists and help them seek new international collaboration opportunities.

In view of the demand for funding for S&T programmes, the Government does not regard it as realistic, in the short term, that Ireland should join large scale international "megascience" projects. The Office of Science and Technology should continue to keep the situation under review.

Government Decision

The Department of Enterprise and Employment has allocated £200,000 in 1996 for new international research collaboration projects.

Performance Indicators

TIERNEY recommended the regular collection and publication of performance indicators relating to research in the third-level colleges. This would help to monitor the quality of the research and to assess the impact, both within and outside the colleges.

The Government supports the principle of using indicators to measure the performance of the colleges in relation to research and to promote the value of research, but notes that real difficulties arise in the development and the assessment of such indicators. Forfás is currently undertaking work to improve the situation in this area.

Social Sciences

The TIERNEY Report noted that the social sciences are not currently considered part of the national science and technology system.

The Government points out that there have been recent developments in this area, such as the allocation of £100,000 to social sciences from the Department of Education Vote and the setting up of a Social Sciences Research Council.

Clarifying and Strengthening the Role of Research in the Third-Level Sector

Research Charter

TIERNEY considered that because of the predominant role which the whole third-level sector – universities and technical colleges – plays in relation to research in Ireland, it is essential to increase substantially the interaction between colleges and enterprises. TIERNEY saw a need to clarify the research policy of the colleges and, thereby, provide a positive signal to academic researchers and industry.

The TIERNEY Report recommended that the colleges should adopt a Research Charter, which would set out clearly a policy of encouraging and rewarding research. It should particularly emphasise involvement with industrial R&D. Academic careers have traditionally been determined by success in the field of research publications. This can adversely affect the careers of academic staff who spend time working with industry and is a major disincentive to industry-college collaboration for all but senior professors. The third-level institutions urgently need to introduce appropriate changes to their procedures for rewarding and promoting staff, to reflect activities outside research publications.

The Government agrees that each third-level institution should set down a clear statement of its mission in relation to research. The Education White Paper accepts the principle that each institution should publish an explicit policy statement in relation to research and the Conference of Rectors of the Universities supports the proposal. The policy statement, or "Research Charter", should set out the institution's active encouragement for research and for interaction with commercial users of research. The policy statement should also cover the career prospects of researchers involved in commercial research.

Government Decision

Each third-level college should publish a policy statement in relation to its research activities ("Research Charter"). The Department of Enterprise and Employment and the Department of Education will be involved in the discussions on the Reserch Charter with the colleges.

Linking Enterprise with Third-Level and Public Sector Research

As well as stressing the importance of improving research linkages between enterprise and third - level colleges, State research institutes and organisations such as the Programmes in Advanced Technology (PATs), TIERNEY pointed out that these bodies should ensure that they devote adequate resources to technology transfer activities. In particular, colleges should appoint technology transfer officers to manage the transfer of technology out of the colleges. The Government supports the recommendations designed to maximise technology transfer from third-level and State bodies.

Government Decision

The Department of Education and the Department of Enterprise and Employment will explore, in consultation with the third-level institutions, how best to maximise technology transfer out of the colleges.

Intellectual Property Rights (IPR)

The issue of intellectual property rights is a serious barrier to industry-college collaboration. Both industry and third-level colleges have a need to develop new intellectual property but they approach it from different angles. IPR is of vital concern to industry, because of the need to keep a new idea or piece of knowledge out of the public domain until it can be exploited for commercial gain. For the academic researcher on the other hand, the priority is often the immediate publication or dissemination of the research results. There is a need for a mutual understanding which respects the needs of both sides, but which encourages practical collaboration.

The TIERNEY Report fully accepted that the dilemma in relation to intellectual property rights can inhibit industry from closer working relationships with the colleges. It recommended that there should be an awareness campaign to alert academic researchers to the need for IPR and the drawing up of a draft model contract for use in industry and the colleges, which would facilitate the collaborative process.

Government Decisions

Forbairt's Intellectual Property Unit will actively promote the development and exploitation of intellectual property among academics and researchers.

The Minister for Commerce, Science and Technology will promote a model contract relating to joint industry-college research work particularly addressing the question of intellectual property rights. Discussions on the issue have taken place between the Industry Research and Development Group and the colleges.

Role of Regional Technical Colleges/ Dublin Institute of Technology

TIERNEY noted the increasingly important role of the Regional Technical Colleges/Dublin Institute of Technology (RTCs/DIT) in regional development via applied research and technology transfer activities. Under the 1992 Acts, these Colleges now have a research function as well as a more general regional development role. The RTCs/DIT have two advantages in this role. Firstly, they are much more widely distributed throughout the regions, and, while close geographical contact is not essential for college/industry interaction, it nevertheless is important, particularly in relation to interaction with small industry. Secondly, the more applied curriculum of the technical colleges is more attractive to small industry. Through the Technology Services Centres Programme, for example, operated by the OST, the RTCs/DIT have developed technology-based centres of excellence in recent years. TIERNEY pointed out the need to promote a greater awareness of these centres, as well as co-ordinating their operations into a network available to regional enterprises.

A detailed submission was made to the Task Force by the Council of Directors of Regional Technical Colleges outlining their belief that it is necessary to strengthen the emphasis on the role of the RTCs in the science, technology and innovation infrastructure, to reiterate their potential as major instruments of regional development and to seek a strong partnership with Forbairt in promoting regional STI development. The RTC Directors proposed a five year national programme to promote STI throughout Irish industry and regions, involving all the third-level sector and the development agencies. The programme would include an STI development plan for each region, the networking of all third-level institutions, increased funding for basic and applied R&D, more support for entrepreneurs, greater emphasis on technology transfer, and the further development of the RTC Technology Centres.

The Government supports the aims and initiatives outlined in the RTC submission and believes that it has already addressed most of the recommendations from the colleges. It considers that Forbairt should continue to develop close working relationships with third-level colleges and consult them formally as appropriate in the preparation of regional development plans.

Government Decision

Forbairt will consult with local university research strengths and with the Regional Technical Colleges/Dublin Institute of Technology in the preparation of its regional development plans and encourage their involvement in developing the innovation capability of companies at regional level.

Mobility of Researchers and Students

The TIERNEY Report noted the trend towards greater mobility between people in colleges –

both students and staff – and industry. It called for an increase in this activity and also for more mobility between the vocational and university sectors, and for increased cross-border mobility where practical.

The Government endorses this recommendation and particularly commends the in-course industrial placements of the RTCs and a number of universities, and advocated their further expansion and development.

Government Decision

The Government has instructed the Department of Education and the Department of Enterprise and Employment to discuss with the universities how to extend their use of in-course industrial placements.

A Case in Point – Iona Technologies

Iona Technologies was formed, as a campus company, in Trinity College in March 1991, with a simple mission to bring the power of Distributed Object Technology to the world. It is currently the world's leading provider of application integration software solutions. The company now employs over 160 people worldwide, the majority of whom are top quality graduates.

The company's founder, Dr. Chris Horn, was a young dynamic lecturer in Trinity College prior to forming his company. He was deeply involved in a number of EU projects and gained invaluable experience in Distributed Object Technology. Chris located his fledgling company in a low cost incubation unit within the college and, in the early stages, the company worked on developing its reputation in the area.

In 1992, the company sold to its first big customer – ICL – and has been growing ever since. Its principal product is Orbix which is currently used by more than 7,000 software developers in over 1,000 companies worldwide. The company has a strong customer base, among whom are Hewlett Packard, Northern Telecom, Motorola and Boeing. In December 1993, Sun Microsystems, a large US multinational, purchased a minority stake in Iona.

DEVELOPMENTS IN SCIENCE AND TECHNOLOGY

Professor Mike Cooley, Tuam Co. Galway
(Chairman, Technology Innovation Associates)

Scientific and technological developments have invariably proved to be double-edged. They produced the beauty of Venice and the hideousness of Chernobyl; the caring therapy of Rontgen's X-Rays and the destruction of Hiroshima.

I always seek in my work to discern both the positive and negative features and to build upon that which is positive. Thus when confronted with the de-skilling effects of some forms of new technology, I initiated the design and development of Human Centred Systems which enhance human skill and ingenuity.

In order to reduce the pollution of internal combustion engined vehicles, I helped to promote the use of electrical drives with permanent magnet motors and in the more long term, the use of fuel cells.

There are now over twenty million people out of work in the EU Member States. This constitutes a tragic waste of society's most precious asset which is the skill and ingenuity of its people. I proposed job creation projects based on socially useful and environmentally desirable products and services. To support this, I have been involved in developing The Technology Exchange (the Product Bank) which offers some 5,000 new products and services and can be accessed electronically.

As we precariously approach the 21st Century, scientists and engineers have a profound responsibility to openly discuss, in a non jargonised fashion, the implications of their work and the policy options open to us. Hopefully, this will lead to a great public debate and lay the basis for a cultural and industrial renaissance where we develop forms of science and technology which will be caring of humanity and our beautiful planet. It will require decision makers and politicians of vision and courage to take this more long term development view.

Improved Education and Training

"It is generally accepted that an effective programme in science education will give children opportunities to investigate and explore their own environment, to formulate and test hypotheses and to be active rather than passive learners. As a result, children will develop a wide range of skills and attitudes relevant to them in everyday life."

TIERNEY Report, page 152

Apart from the contribution of the third-level education sector, the role of primary and second-level sectors is critical to the development of an S&T culture. This Chapter deals with the need for increased attention to science and technology subjects in primary and second-level education. It also refers to the need for the continuous development of a highly skilled and technologically competent workforce to meet the challenge of competitiveness for Irish industry.

Decisions of the Government

- The Department of Education and the National Council for Curriculum and Assessment (NCCA) will continue to promote a more practical approach to the teaching of S&T-related subjects in primary and second-level schools. The Government commits itself to addressing this issue as resources allow and in the context of the annual Estimates.
- The Department of Education will continue to undertake a series of initiatives to give practical effect to the principles set out in the White Paper on Education, which include a strong commitment to equality. The Department of Equality and Law Reform will also support initiatives for the promotion of equal opportunities in STI.
- The Department of Enterprise and Employment will produce a White Paper on Human Resource Development in the near future.
- The Government has established "Teastas", the National Certification Authority, responsible for the development, regulation and supervision of the certification of all non-university third-level programmes and all further and continuing education and training programmes.
- The Minister for Commerce, Science and Technology recently launched the R&D Management Development Scheme, aimed at encouraging companies to develop explicit plans for increased innovation via research and technology development. The scheme will provide training in R&D and innovation management for companies, in line with "best international practice."

Introduction

Our essential focus in this White Paper is Ireland's weak National System of Innovation and its associated mutually reinforcing complex of vicious circles. The National System of Innovation is not simply a physical or institutional thing. It also embraces aspects of the national culture in the broadest sense. From this point of view, the old saying, "Give me the child and I will show you the man" emphasises the critical role of the education system in shaping individual outlooks and in the aggregate, the national outlook.

Many studies in the past, both national and international, have pointed out that the Irish education system is enormously weighted in favour of the classical humanist tradition. Related to this, there also remains the perception that qualification in the professions such as accountancy and law, or banking or medicine, provide safe and ultimately opulent, career options, the key to the good life for oneself, if not for all. To help change this situation, the curriculum needs change. In terms of our 'contractarian' inputs/outputs approach, the system needs to deliver the new skills required by society for the world of work, including problem-solving, communication, team-work skills, dealing with change, self-responsibility and risk-taking.

The present balance in Irish education transmits itself to the business sector and the wider society, making it difficult for enterpreneurs, employers, managers, employees and society to adapt to new business practices and technologies and hindering the economy's capacity to innovate.

Companies and the community are faced increasingly with having to react to innovative and technological developments world-wide and to demand the necessary skills to compete. If we are to develop a more positive culture towards science, research, technology and innovation in Irish society then one of the most important determinants will be the education system. The education system is the foundation stone on which to achieve the State's long-term ambition – the construction of a strong National System of Innovation.

Enterprise and society in general have a growing need for researchers, engineers, technicians, the curious and adventurous. The Irish education system, broadly defined to include the training system, must provide these in sufficient quantity and with the necessary abilities and skills. To do so, the education and training system at all levels must be improved to stimulate greater interest in the sciences and engineering and related subjects. It must also engage with another pressing requirement, the need for citizens and companies to engage in continuous and life-long learning.

Delivering Society's Required Outputs: S&T in schools

TIERNEY concluded that one of the main factors which contributes to the general lack of public understanding of science and technology in Ireland has been the comparative lack of scientific and technological training in our schools in the past. An early and structured introduction to, and a continuous grounding in science and techno-logy, are essential for the citizen's full and fulfilling participation in the modern world.

The Government is of the view that the

science and technology syllabi in the curriculum must be responsive to the needs of a modern society and economy. The White Paper on Education points out that scientific and technological developments have an enormous influence on our lives, whether through their economic and social effects or through their impact on individual lifestyle. In a fast-changing world, it is important that people are able to understand such innovations and to evaluate their implications. In effect the system must be capable of producing young people who are technologically and scientifically literate. At primary level the development of a new science programme will form an integral part of the review of the social and environmental programme, now in preparation. At the second level, either science or a technological subject will form part of the core programme for each student in junior cycle.

To be fully effective, however, science and technology studies must be in line with modern scientific thinking and satisfy the requirements of educational bodies, industry and citizens. Through the provision of stimulating activity they must expose and develop the natural curiosity of young people. If there is to be a sea-change in the cultural attitude to science, technology, innovation and risk-taking, the curriculum needs to place emphasis on the relevance of science; the everyday impact of technology; and to inspire a sense of curiosity and adventure- rather than teach science merely as an academic subject.

Nowhere is this more obvious than in relation to the overwhelming impact of information technology and the arrival of the information economy and the information society. As computers become essential to almost all aspects of our daily lives, the need to introduce children to their use at the primary level is all too apparent. At that stage of development children have a natural aptitude to absorb new skills without any sense of apprehension and a strong spirit of adventure. The opportunity to introduce science and technology as the children become computer literate should be grasped. Information technology is more than a subject on the curriculum. It is, of itself, a whole new means of learning.

This is underlined most recently in the EU Commission's Action Plan for a European Education Initiative (1996-1998) called "Learning in the Information Society". The European Council acknowledges the need to ensure that schools are not left out of the Information Society and aims that the Union, along with the Member States, should ensure that all schools, universities and libraries are connected to the knowledge networks by the year 2000 in order that all young Europeans can benefit fully from the multimedia revolution. The Action Plan is intended to reinforce activities at national and local level to connect schools to communication networks, train instructors and develop products to meet pedagogical needs.

The TIERNEY Report recommended that the National Council for Curriculum and Assessment (NCCA) should continue its work in facilitating practical S&T-related subjects on the curriculum, at primary and second level. In line with the Education White Paper, the Government endorses the efforts in recent years of the NCCA, in its advisory role to the Minister for Education. The NCCA has brought forward proposals for

improved teaching of science and technology (including IT), emphasising the vocational dimension of the subject, and there will continue to be improvements in the curriculum in this regard. There are strong arguments for making technology and enterprise mainstream, even mandatory, subjects, especially at second level and thus to encourage more students to study science and engineering at the third level.

The Government accepts that there are considerable resource implications to achieve this objective, including the necessary materials, equipment, experimental facilities and specialised teacher training. Such resources must be available on an equitable basis throughout all schools rather than allow a two-tier approach to the teaching of science and technology to develop.

Once again the availability of computers and the use of information technology is a clear case in point. As Irish Tech Corps (the partnership between DCU's Centre for Teaching Computing and the Irish Software Association) points out, "Information technology in schools in Ireland today is not well supported. Few schools are equipped with adequate computing facilities. Many schools have none. The potential of computing to enrich the way subjects are taught is not being realised. Computing as a discipline is not on the curriculum."

The Government accepts that it is desirable that all schools should be equipped to a high level to learn and avail of information and communications technologies and to have the skills to maximise the educational value of these technologies. This in turn will allow individual schools and students to communicate with other schools at home and abroad and derive full benefits from access to international information networks.

To help address these issues the scientific, technical and industrial community should be encouraged to develop links with schools (e.g. by providing career guidance) in order to stimulate young people to broaden their experience of science and technology and to prepare for productive employment.

Government Decisions

The Department of Education and the NCCA will continue to promote a more practical approach to the teaching of S&T-related subjects in primary and second-level schools. The Government commits itself to addressing this issue as resources allow and in the context of the annual Estimates.

In addition, the Minister for Commerce, Science and Technology has asked Forfás to prepare proposals for the promotion of science and technology in schools as part of a wider S&T awareness campaign (see Chapter Thirteen).

Training and Skills for Employment

We justifiably pride ourselves in our education system as being among the best, although it does need now to adapt, change focus and culture. Society's contract with the education system requires it to reflect changing circumstances and new pressures.

We pride ourselves also in having a highly educated workforce. This is true for the present generation. It is less true of the older workforce and managers and those employed in older

companies and traditional industries. Critically, in these companies and industries, managements are reluctant to invest in training.

Until perhaps fifteen years ago, those entering the workforce, whether directly from school or after additional training, would have considered that the skills with which they started their working lives would see them through to the end of their careers. But times have changed. Product life cycles are now much shorter and process technologies are changing more rapidly and becoming more sophisticated. In business, as in our daily lives, information technology and its many applications have become pervasive.

Organisational structures, in both the public and private sectors, require ongoing adaptation. In addition, the skills required among managers and workers to derive full benefit from new technologies, to understand, plan, control and participate in the innovation process are constantly changing. This new environment requires a much greater emphasis, by enterprises and their managers, on training needs than at present. It demands life-time learning.

In recognition of the rapidly changing technology and innovation needs in the workplace, TIERNEY stressed the need for companies to engage in continuous training. The Report recommended that:

- there should be a formal mechanism to ensure collaboration and co-ordination between the main participants in the STI skills system, i.e. Higher Education Authority (HEA) / FÁS / Forbairt / National Council for Educational Awards (NCEA) / Third-Level Sector/ Industry;
- companies must have access to a wide range of skills and talents, based on an understanding of STI;
- course content should be adjusted and adapted continuously, to reflect changing corporate requirements;
- a re-distribution of FÁS resources should be put in place to achieve greater emphasis on skill development and re-training for the employed.

The Government endorses the need for a strong emphasis on STI training of employees within firms and for new initiatives to achieve this. In an era when the nature of work is rapidly changing, there is a need for a flexible, adaptable and innovative workforce. It is important, therefore, that the National System of Innovation has training and education providers who are familiar with what is currently happening in industry and with what enterprises perceive as being their requirements for the future.

The Programme for Government includes a commitment to produce a White Paper on training. The White Paper, which will include wider aspects of human resource development, is currently being prepared within the Department of Enterprise and Employment. It will reinforce the need to develop a proactive education and training system, which can respond to the changing needs of competitive business and to the wider needs of our society.

The Government agrees that training programmes should make particular provision to accommodate new technological developments and to emphasise the importance of science, technology and innovation across the full range of activities of enterprises, private and public, and the wider public service.

In Chapter Eleven, there is reference to

the prospects and attempts to match post-graduate output in S&T disciplines with the research and skills needs of the economy. This raises the wider question of the supply/demand equilibrium in undergraduate and technician output. Whereas in the past an over-supply situation has allowed us to cope generally, we are now experiencing shortages in some key areas. For example, there is concern about the availability of computing science graduates to meet the demands of the electronics sector. This problem must be seen in its international dimension and is not peculiar to Ireland.

With the large and growing numbers being routed through the third-level system and the increasing intensity of the points race, there is a need for a conscious effort to ensure that course availability and content is linked to the needs of the economy and the likely sources of employment opportunities. This is as much a case of the proper balance among the various courses provided by the colleges as it is about increased numbers in selected disciplines.

This is not solely an S&T policy issue but is for resolution also in the context of a consistency in approach between education policy and policy towards human resource development in the economy.

Government Decisions

The Department of Enterprise and Employment will produce a White Paper on Human Resource Development in the near future. The Government endorses the need for greater emphasis on skill development and re-training for the employed and on the importance of training for innovation across the full range of a firm's activities.

The Minister for Enterprise and Employment has established a steering committee to develop a national information society strategy and action plan which will address aspects of life and work affected by the new information technologies.

Also at the Department of Enterpise and Employment, a special unit has been established to assist the social partners in developing 'new ways of working', increasing labour-management co-operation and strengthening partnership at enterprise level.

Management of R&D and Innovation

TIERNEY identified a need to promote the management of technology and to provide assistance to firms in this regard. There is ample evidence that the attitude of the chief executive and senior managers to innovation is a major determinant of an enterprise's performance. Even for managers with a positive attitude, there may be much to learn about overall technology management, so that all options, from in-house R&D to external technology acquisition, can be explored and exploited.

Training courses are starting to be developed in the areas of technology management and innovation but industry has been somewhat slow in taking up these initiatives.

Government Decision

The Minister for Commerce, Science and Technology recently launched the R&D Management Development Scheme, aimed at encouraging companies to develop explic-

it plans for increased innovation via research and technology development. The scheme will provide training in R&D and innovation management for companies, in line with "best international practice".

Training Certification System

The TIERNEY Report points out that the provision of training and education for STI skills in Ireland is diffuse and is not sufficiently focused or active. The Report recommended that:

- there should be a system of certification of training providers;
- a national "training mark" should be established to give recognition to good training practice .

The Government fully supports the need for a national certification system for training providers and for a quality assessment system for private sector training providers. It has established a new Irish National Certification Authority, "Teastas", which will be responsible for the development, regulation and supervision of the certification of all non-university third-level programmes and all further and continuing education and training programmes.

The Government supports the recommendation that a national "training mark" should be established. The awarding of such a training mark would be an effective way of counteracting the present reluctance of many firms to invest in developing the knowledge and skills of their employees, on the grounds that they might be poached by competitors. However, further work is required in this area to develop the standards for such a mark.

Government Decision

The Government has established "Teastas", the National Certification Authority.

Gender Balance

The TIERNEY Report recommended that the relevant authorities (i e. the Department of Education and the Department of Equality and Law Reform) should examine the gender imbalance in the numbers studying S&T-related subjects.

Work done by Women in Technology and Science (WITS) has highlighted the disparities that exist in all areas of STI in Ireland. WITS' view is that the State *and* industry lose out if female S&T graduates are not given equal opportunity to use their talents in the business sector, including up to management level. In their opinion the current gender imbalance underpins all the recommendations in the TIERNEY Report and there needs to be an awakening of "gender consciousness" among top-level management and decision-makers.

There are two aspects to the issue of girls' participation rates in science subjects – firstly, the low level of participation of girls as such, and secondly, with the entrance requirement of higher level maths and another science subject for engineering applicants to third-level, the participation by girls in third-level engineering courses is also very low.

There are already a number of initiatives taking place on the issue of girls' participation rates in science subjects. The Department of Education has done significant pilot work – for example the intervention projects developed by its Science Inspectorate – to promote science sub-

jects and increase girls' participation rates in these subjects. There have also been initiatives under Employment NOW (New Opportunities for Women) – two courses are run in DIT Bolton Street and Cork RTC – to introduce girls to engineering.

On another aspect, the Government is of the view that Departments and agencies which operate S&T programmes should take full cognisance of equality opportunities in progressing policy in this area. Consideration of the contribution of S&T in the services industry should take account of the prominent role of women in such employment, including the caring sector. Generally the Government is aware that S&T can greatly assist in facilitating work organisation options, thus ensuring easier reconciliation of family and work responsibilities, a better sharing of such responsibilities between men and women and a greater prospect of retaining highly educated, qualified, experienced and skilled women workers in the workforce.

Government Decision

The Government strongly supports the need for continuous review of the gender balance in S&T-related subjects in our schools. The Department of Education will continue to undertake a series of initiatives to give practical effect to the principles set out in the White Paper on Education, which include a strong commitment to equality. The Department of Equality and Law Reform will also support initiatives for the promotion of equal opportunities in STI.

A Case in Point: Aer Lingus Young Scientists 1996

Elsie O' Sullivan, Rowena Mooney and Patricia Lyne, from Scoil Mhuire, Portarlington, were the Aer Lingus Young Scientists for 1996. What follows is their account of what Science and Technology means to them.

"Being Aer Lingus Young Scientists, Science and Technology mean the world to us. Science has brought us to where we are today, it has moulded our lives into what lives they are, now that we are Young Scientists!

The Aer Lingus Young Scientists Competition aroused our growing interest in Science over two years ago. Through our first years experience partaking in the contest, we learned how to apply hard work and expert knowledge and perseverance into doing a winning project. From this experience, we have learned to open our minds and take on the challenges of life.

We are now living in the 20th Century and our lives are beginning to revolve around the world of Science and Technology more and more every day. We, as Young Scientists, have learned over the past year, that we can come to understand and use this vast field to make this world a better place."

FAMOUS IRISH SCIENTISTS

Ernest Walton (1903-1995)

The only Irish-born scientist (so far) to win a scientific Nobel Prize has been Ernest Walton. Ernest was born in Dungarvan, Co. Waterford, the son of a Methodist Minister. As a young man in Cambridge University, he collaborated with John Cockcroft (1897-1967) in the building of a linear accelerator which could accelerate protons (hydrogen nuclei) to energies of 700,000 electron volts. With this apparatus, he and Cockcroft "split the atom" in 1932. For this work, they jointly received the Nobel Prize for Physics in 1951. It was the beginning of accelerator-based experimental nuclear physics, which continues to teach us so much about the nature of matter.

What he and Cockcroft actually did in 1932 was to bombard the element lithium with their accelerated protons. These were energetic enough to shatter the target lithium and produce alpha particles, or helium nuclei. They had achieved a transmutation of the elements – the conversion of one element into another – by entirely artificial means. This had long been the goal of the alchemists. And in carrying out this transformation, they were able to verify Einstein's famous equation $E = mc2$ (energy equals mass times the speed of light squared). The mass of the two alpha particles was less than that of the lithium and proton, the missing mass being converted into energy. This achievement was one of the great landmarks in physics.

While he remains the only Irish-born scientific Nobel Laureate, contrasting with four in literature – Yeats, Shaw, Beckett and Seamus Heaney – there are other scientific and medical Nobel prise winners with Irish connections. The mother of Guglielmo Marconi (physics 1909) was Annie Jameson of the Irish distilling family. Erwin Schrodinger (physics 1933) worked at the Dublin Institute for Advanced Studies from 1940-1956 and became an Irish citizen in 1948. Richard Millington Synge (chemistry 1952) came from a Liverpool Irish family.

Improved Awareness of Science, Technology and Innovation

"We strongly advocate the need for a new vision of innovation in Ireland which will provide the motivation for enterprises, individuals and the public sector and believe that this should be based on a national system of innovation. The many factors, public and private, which interact to stimulate and support innovation constitute the elements of such a system. Partnership and participation at both national and local levels are critical requirements. Paramount to this vision is a change in our cultural approach to risk-taking and the need for a long-term view, in commitment and funding, by the Government."

TIERNEY Report, page 23.

All of the decisions in relation to specific programmes, sectors or issues will have a lesser impact unless there is a generally improved public perception of science and technology. This Chapter deals with the need to develop a dedicated programme for the promotion of STI.

Decision of the Government

The Government has decided to provide financial support for a three-year professional campaign, to be organised by Forfás, which will promote improved awareness of the importance of science, technology and innovation. The campaign, commencing in 1996, will be targeted particularly at decision-makers in the public and private sectors and also at the education and business sectors, the media and the general public.

Introduction

This is a White Paper on science, technology and innovation (STI) policy. It represents but the latest step in what is intended as a new, continuous process of assessment and implementation of policy in one specific and now crucially important area of public policy. The ambition of the political and administrative state in this area is the objective recommended by TIERNEY, the creation in Ireland of a strong National System of Innovation.

While STI policy has its own agenda, it is also part of a wider framework, that of public policy generally. As with the rest of public policy, STI policy comprises ambitions or intrinsic objectives and instrumental goals, means towards those ends we seek to secure. As regards our means, the requirements are for relevance, workability, value for money, accountability and progress towards our ambitions.

The political philosophy that informs the White Paper is that good government will be achieved through the application of the 'contractarian' philosophy, within the framework of rational decision-theory. There are, therefore, three great themes that inform this White Paper. These themes are:

- the necessities of the democracy: to provide citizens with a means of contracting with, instructing and measuring government in respect of STI policy;
- the achievement of the appropriate mix of private provision by citizens with that of collective action by society, through the State, in pursuit of STI policy objectives;
- the weight to be given to the local circumstances of history and the moment – or what we might call the 'stamp of national characteristics' – in the framing and implementation of STI policy.

The requirement of the elective rule, which is ultimately for good government, is paramount. The questions of the appropriate private/collective mix and the configuration of collective action are insoluble outside the democratic system, which operates to generate an even "rough-and-ready" social welfare function, through the mechanism of elections, while the necessity to address the "national characteristics" and current

circumstances, must constantly be borne in mind. All of this is the meat of politics.

The Science and Technology Debate

The ambitions and the detailed measures adopted and implemented under the rubric of STI policy are crucially important to the well-being of the nation, society and the economy. The achievement of a strong National System of Innovation – embracing both the institutions of the system and wider culture, values and attitudes – is central to securing enhancement of the trading performance and the growth of indigenous firms and stronger linkages between foreign investment in Ireland and the home economy. It is therefore central to the achievement of wider social and economic ambitions: the reduction in the rate of unemployment; the elimination of long-term unemployment; the achievement of greater equality of opportunity (both between the classes and in terms of gender) and the eradication of the dualism that characterises our economy and the ambition of sustainable full employment over time.

Science and technology as such, in their focus and application, are also increasingly bound up with huge moral and political-philosophical issues. The biological sciences are dealing with the very building blocks of life. Trends and developments in information technology pose problems for well-established and long-accepted principles, such as universal service obligation.

Yet in Ireland, despite all of this, there is a weak representation of STI issues in public affairs and a general lack of awareness shown by the public in STI issues. The only initiative which has truly caught the general public's imagination is the Aer Lingus Young Scientists' Exhibition.

TIERNEY contrasted the situation in other developed economies – where governments constantly strive to raise the general public's level of understanding of scientific and technological issues – with the absence of such an approach in Ireland. It felt that Ireland's capacities will never be fully realised until there is an acceptance of STI's importance to our economic and social development.

The media, scientists and the business community generally, as well as government, all come in for critical comment as regards attitude to and understanding of the role of STI in national development.

The Irish media, TIERNEY observed, has a low level of interest and expertise in covering STI. This is true as regards the print media and broadcasting. TIERNEY contrasted this situation with that in the United Kingdom, to pick an example, where many of the daily and Sunday newspapers provide comprehensive coverage of the subject matter. BBC radio has over a dozen programmes with a special interest in STI issues and, at any given time, either BBC or ITV broadcasts at least one science-based TV series. In contrast, Irish media coverage is led by public relations activities, 'good news' stories. "PR-led items make limited demands on editorial resources and are easy for the mainstream media to handle."

Scientists in Ireland, TIERNEY concluded, "have not, in general, been good communicators, assuming their work is of obvious merit and not expecting the ordinary public to understand." The cultural norms of the profession are privileged and "communication with outsiders is not considered necessary."

The low level of R&D performed in Ireland is a central concern of this White Paper. But, as TIERNEY pointed out, "what this means is that the importance of technology and the competitive advantages it offers are not fully appreciated by all sectors of Irish industry." The failure of the majority of Irish firms to appreciate the contribution which investment in STI can make to maintaining and upgrading their business reflects a wider national disaffection with these matters. A negative attitude to the process of commercialising and exploiting STI undoes much of the specific measures aimed at increasing innovation in firms. The Report singled out the banks as not being 'risk friendly'. Yet, it observes, "the financial services sector above all has itself been transformed through the application of technology."

In the area of awareness, our aim must be to bring about a significant cultural shift in attitudes and to bring about better communication, interaction and mutual understanding between the scientific community, industry, government, the media and the public. To this end TIERNEY recommended that a separate fund be set up and administered by Forfás, to develop specific initiatives.

The Government endorses the need for a strong promotion of 'awareness' of the importance of S&T to economic and social development and of specific activities across the range of scientific endeavours.

Government Decision

The Government has decided to provide financial support for a three-year professional campaign, to be organised by Forfás, which will promote improved awareness of the importance of science, technology and innovation. The campaign, commencing in 1996, will be targeted particularly at decision-makers in the public and private sectors and also at the education and business sectors, the media and the general public.

However it is not simply a matter of extra public expenditure. The Government takes the view that the implementation of the national S&T planning structures could, in itself, have a significant effect on the level of awareness. It concludes that, in each area where S&T activity takes place, there is a need for greater awareness, and a small proportion of overall expenditure in each area for promotion purposes would provide very significant resources.

Such an approach to the promotion of greater awareness, and appreciation of the contribution which science, technology and innovation can make to economic and social development in Ireland, could contribute greatly to achieving structural change and a consequent increase in both national and firm-level competitiveness.

There are various initiatives taking place to promote STI, such as science literature, open days, seminars, conferences, awards and exhibitions and the Government feels that, in the first instance, there could be better orchestration and co-ordination of existing activities.

Public awareness of STI is not the sole responsibility of any one Department or agency and there are a number of private sector organisations active on this front.

The Government is encouraged that, since the inauguration of the STIAC process,

there have been a number of positive developments. For example, RTE radio runs a series on S&T; the Irish Times has a weekly column; scientists themselves organise an annual summer school.

Each of these in itself is modest but together they represent a breaking out from the inertia and the development of a new approach and momentum. It is up to us all to build on this.

A Case in Point - Forfás STI Awareness Campaign

Nothing Stays The Same

Changing Times Call For New Directions

The world is going through a technological revolution at present and we in Ireland need to play our part.

As a nation, we need to learn more about science, about technology and most especially innovation - the key to our future well - being and competitiveness in the global economy.

If we can innovate, we can participate - it's the way forward.

The Science, Technology and Awareness Programme is managed by FORFAS - the policy and advisory board for Science, Technology and Industrial Development.

OUR FUTURE STARTS HERE

Conclusion by the Minister for Commerce, Science and Technology

Taking all of the foregoing into account, this White Paper is something of a hybrid. It is a White Paper with, at times, a tint of green to it. It engages in and sets out a discussion agenda, as well as a definite programme of actions by the Government, following on from the TIERNEY Report and the work of the Task Force established last year to advise the Government on the prioritisation of STIAC recommendations.

In Part One of the White Paper the reader will have found a broad philosophical discussion of the rationale for what we are doing. One critical feature of what we are doing is strongly and overtly linking S&T to Innovation and also placing it in the context of national development. S&T will be evaluated by its ability to contribute to wider national goals, as a means to achieving them rather than as an end in itself. In Part Two, the reader will have found some discourse and agendae for the future on particular topics such as the role of education, awareness of S&T and national S&T strategy and structures.

A White Paper normally marks the end of discussion. However, in the S&T arena, we need continuous public debate to raise and improve its profile, to establish investment priorities and to ensure that the country derives maximum benefit from that investment.

Since taking up the science portfolio in Government I have discovered that scientists are good at communicating with each other. But that internal discourse is conducted in the dense language of the learned journal and the scientific paper. Scientists are, I have learned, however, less practised in communicating with the wider society and mostly feel themselves under little if any obligation to do so. As science becomes central to all of our lives, I suggest that they must.

The worst thing that could happen, following publication of the White Paper, is that the debate will fizzle out. Government has played its part by first instigating the STIAC process and now producing this White Paper. But governments cannot be expected to both lead the debate and provide the response. It is very much the responsibility of all of the S&T community to generate discussion on policy and practical concerns and to demonstrate their relevance to the issues of the day. Visibility, followed by responsibility and accountability, is the way forward.

Pat Rabbitte TD
Minister for Commerce,
Science and Technology

Notes

1 Amartya Sen, *"Wrongs and Rights in Development"*, Prospect, October 1995

2 For an account of the contractarian analysis of the democratic system, see Jean Hampton, *"Contract and Consent"*, in A Companion to Contemporary Political Philosophy, edited by Robert Goodin and Philip Pettit (published by Blackwell). See also Michael Laver, *"The Politics of Private Desires – the Guide to the Politics of Rational Choice"* (published by Penguin Books).

3 Defined by George Ross, in *"Jacques Delors and European Integration"* (published by Polity Press/Blackwell Publishers) as "a humane social order based upon the mixed economy, civilised industrial relations, the welfare state and a commitment to basic social justice" with its roots in "the Social Democrat-Christian Democrat mainstream of continental European politics. The conviction that European capitalist societies both were and ought to be different was shared in this mainstream. ... In it societies were more than markets, citizenship more than consumption, and government more than an economic traffic squad. People belonged to moralised collectivities which negotiated with one another for the good of all. Citizenship involved solidarity with others. Government, beyond stimulating economic activity to provide welfare, should craft a range of public goods, not only because of market failures and "externalities" but in response to the demands of solidarity."

4 From the economic-theoretic and legal standpoints, innovation is not the same as invention. An act of invention is a novel idea that passes the patent test. It involves an inventive leap that creates something novel, useful and critically, non-obvious to a person skilled in the relevant art. Therefore, it wins a temporary property right, patent right. In exchange for this grant, the inventor must put his or her advance in knowledge into the public domain. This is the core of the patent from the standpoint of the State. From the vantage of the inventor the prospect is, through commercial exploitation, one of profit.

An invention may be viewed as an innovation of the highest order, and at one end of the innovation spectrum. At the other end of the continuum are the myriad small changes in technique that represent incremental advance, the process of continuous improvement. All inventions are innovative, but not all innovations are inventive steps.

A question arises. Should we put a premium on invention as opposed to innovation.

The immediate instinct might be to put a premium on invention. But who is to say that an invention is better than an innovation? An invention may be far removed from immediate commercial exploitation (as a result of, for example, the need for testing, trials and licensing), while an innovation can generate a quick payback.

5 In a very real sense, we have returned to the themes of the nineteenth century. We are

undergoing a new industrial revolution. The original industrial revolution happened in a world of imperialism, in which there was free trade, free movement of capital and growing companies with global ambitions. Today the GATT agreements have secured free trade and the dismantling of exchange controls have re-created free movement of capital. In the nineteenth century also, there was an explosive outgrowth of new knowledge from the universities, particularly in chemistry and physics, that was capable of rapid adaptation and absorption into commercial business, indeed spawning entirely new industries. Strong links grew up between universities and big companies. A new breed – the scientist-entrepreneur – emerged. At the same time, incremental change, changes of technique, proceeded at a rapid pace. Innovation in all of its shapes and guises was the dominant feature of the industrial system.

We are revisiting the territory of the nineteenth century, undergoing a period of intense growth of knowledge, the emergence of entire new industries, rapid changes of technique, new ways of working and significant social upheaval. The era of stability, of 'management science', production planning, volume and standardised production (roughly the 1920s to the early 1980s) has passed.

6 The production of an annual science budget and plan was, in fact, the intention behind some of the legislative provisions in the 1987 Science and Technology Act, particularly Sections 8(3)(b), 8(3)(c), 9(1), 9(2), 9(3), 9(4) [see APPENDIX 3]. The provisions were never effectively implemented because of the absence of the necessary support network. However, with the establishment of a Cabinet Committee and Inter-Departmental Committee, the Government believes that these provisions can begin to be utilised as envisaged. The Government will, if necessary, be prepared to review this position and bring in further supporting legislation to ensure the success of these provisions.

7 There is already a Research and Technological Development (RTD) co-ordinating committee established under the Operational Programme for Industrial Development 1994-1999, which monitors the EU Structural Funds spending on research and technology across all Government Departments and which would be complementary to, and provide a model for, the work of the Inter-Departmental Committee.

Acronyms

BERD	Business Expenditure on Research & Development
BES	Business Expansion Scheme
BRI	BioResearch Ireland
CERN	Centre Européen de Recherche Nucleaire
DIT	Dublin Institute of Technology
EC/EU	European Commission/European Union
EN	European Standard
EPA	Environmental Protection Agency
ERDF	European Regional Development Fund
ESA	European Space Agency
FAS	Irish Employment and Training Authority
GDP	Gross Domestic Product
HEA	Higher Education Authority
IPR	Intellectual Property Rights
IRDG	Industry Research and Development Group
IT	Information Technology
MNEs	Multinational Enterprises
NAB	National Accreditation Board
NCCA	National Council for Curriculum and Assessment
NCEA	National Council for Educational Awards
NESC	National Economic and Social Council
NMRC	National Microelectronics Research Centre
NOSTI	National Office of Science, Technology and Innovation
NSAI	National Standards Authority of Ireland
NSI	National System of Innovation
NTAP	National Technology Audit Programme
NTBA	National Technology Brokerage Activity
OECD	Organisation for Economic Cooperation and Development
OP	Operational Programme
OST	Office of Science and Technology
PAT	Programme in Advanced Technology
RTC	Regional Technical College
RTD	Research and Technology Development
RTE	Radio Telefis Eireann
S&T	Science and Technology
SME	Small and Medium Sized Enterprises
STI	Science, Technology and Innovation

Appendix 1 – Task Force on the Implementation of the STIAC Report

Terms of Reference

1 The Government has established a Task Force to progress the recommendations in the Report of the Science, Technology and Innovation Advisory Council and to advise on how they can best be brought forward for implementation.

In order that the work of the Task Force is given full priority, it will be overseen by a Cabinet Committee to ensure that the necessary political direction, guidance and urgency is given to its work.

2 The Terms of Reference of the Task Force are:

- to identify and advise on recommendations capable of immediate implementation;
- to identify and advise on recommendations which require to be implemented in the context of the 1996 Estimates and Finance Bill;
- to identify longer term issues and to advise on their implementation.

3 The Task Force will refer its deliberations to the Cabinet Committee, indicating:

- recommendations which the Task Force agrees can be implemented as proposed in the STIAC Report;
- recommendations which the Task Force agrees should be implemented but in a manner different to that proposed in the STIAC Report;
- recommendations which the Task Force agrees should not be accepted;
- recommendations on which there is not final agreement within the Task Force and which require a decision by the Cabinet Committee or further guidance to enable the Task Force to come to an agreed position.

Appendix 2 – Background to Task Force Deliberations

The examination of the TIERNEY Report by the Task Force was undertaken against the background not only of the work of the STIAC, including the wide range of consultancy and secretariat reports at the Council's disposal, but also of:

- The Sub-Programme for Research and Development of the Operational Programme for Industrial Development 1994-1999, which will involve total public and private expenditure of £406 million over the period. The Sub-Programme is divided into four measures –
  Measure 1 - Industry R&D Initiative
  Measure 2 - Industry/Third Level Co-operation Services
  Measure 3 - Human Resources Development
  Measure 4 - Research Support
  The Operational Programmes in other areas (e.g. Environment, Agriculture, Marine) also involve expenditure on related R&D activities;

- the Strategic Management Initiative in the public service, which is co-ordinated by the Department of the Taoiseach;

- the work carried out by Forfas, the Government's industrial and technological policy advisory agency, on behalf of the Minister for Enterprise and Employment under the title "Shaping Our Future: A Strategy For Enterprise In The 21st Century" where technology is treated as a core issue;

- ongoing work in the Department of Enterprise and Employment on its Enterprise Strategy Initiative which is taking a short to medium-term perspective on national industrial and technological development;

- the Department of Education's White Paper, "Charting Our Education Future" published in May 1995;

- reports of organisations such as the European Commission, (e.g. the Delors White Paper on Competitiveness) and the OECD in Paris, (e.g. the Technology and Economy Programme – TEP) and the ongoing work on National Systems of Innovation and technology and industrial policy;

- the work being done in a number of OECD countries – including the Nordic countries and Canada – on policies for science, technology and innovation, which has allowed the Irish situation to be seen in a wider international context.

Number 30 *of* 1987

SCIENCE AND TECHNOLOGY ACT, 1987

ARRANGEMENT OF SECTIONS

PART I

PRELIMINARY AND GENERAL

PART II

ADDITIONAL FUNCTIONS OF AGENCY

BAILE ÁTHA CLIATH:
ARNA FHOILSIÚ AG OIFIG AN tSOLÁTHAIR.

Le ceannach díreach ón
OIFIG DHÍOLTA FOILSEACHÁN RIALTAIS, TEACH SUN ALLIANCE,
SRÁID THEACH LAIGHEAN, BAILE ÁTHA CLIATH 2,
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ACTS REFERRED TO

European Assembly Elections Act, 1977	1977, No. 30
European Assembly Elections Act, 1984	1984, No. 6
Industrial Research and Standards Act, 1961	1961, No. 20
Industrial Research and Standards (Amendment) Act, 1979	1979, No. 33
National Board for Science and Technology Act, 1977	1977, No. 25

Number 30 *of* 1987

SCIENCE AND TECHNOLOGY ACT, 1987

AN ACT TO COMBINE THE FUNCTIONS OF THE NATIONAL BOARD FOR SCIENCE AND TECHNOLOGY AND THE INSTITUTE FOR INDUSTRIAL RESEARCH AND STANDARDS IN A SINGLE BODY AND TO PROVIDE FOR RELATED MATTERS. [23*rd December*, 1987]

BE IT ENACTED BY THE OIREACHTAS AS FOLLOWS:

PART I

Preliminary and General

Short title.

1.—This Act may be cited as the Science and Technology Act, 1987.

Commencement.

2.—This Act shall come into operation on the first day of January, 1988.

Name of Agency.

3.—The body heretofore known as the Institute for Industrial Research and Standards shall be known as Eolas—The Irish Science and Technology Agency and may provide itself with a new seal.

Definitions.

4.—In this Act—

"the Act of 1961" means the Industrial Research and Standards Act, 1961, as amended by the Industrial Research and Standards (Amendment) Act, 1979;

"the Agency" means Eolas—The Irish Science and Technology Agency;

"the Board" means the Board of the Agency;

"the dissolved body" means the National Board for Science and Technology dissolved by *section 8 (7)* of this Act;

"functions" includes powers and duties;

"institution" means any institute, college, laboratory, office or service (whether under the control of a Minister or otherwise) which is wholly

or partly engaged in research and development or any other activity related to science or technology;

"the Minister" means the Minister for Industry and Commerce.

Orders.

5.—(1) The Minister may by order amend or revoke any order made by him under any provision of the Act of 1961 or this Act.

(2) Every order under this Act shall be laid before each House of the Oireachtas as soon as may be after it is made and, if a resolution annulling any such order is passed by either House within the next twenty-one days on which that House has sat after the order has been laid before it, the order shall be annulled accordingly but without prejudice to the validity of anything previously done thereunder.

Repeals.

6.—The following enactments are hereby repealed:

(*a*) in the Act of 1961, sections 14, 17, 25 (5), 34, 40, 41 and 42;

(*b*) the National Board for Science and Technology Act, 1977.

Expenses.

7.—The expenses incurred by the Minister in the administration of this Act shall, to such extent as may be authorised by the Minister for Finance, be paid out of moneys provided by the Oireachtas.

PART II

Additional Functions of Agency

Functions in relation to science and technology.

8.—(1) The Agency shall, in addition to any functions assigned to it by or under the Act of 1961, have the following general functions heretofore assigned to the National Board for Science and Technology—

(*a*) to act under the Minister as a body having responsibility for the furtherance of science and technology,

(*b*) to advise the Government or the Minister on the Agency's initiative or at the request of the Minister on policy for science and technology and related matters,

(*c*) to promote the co-ordination of public investment and of public with private investment in science and technology and to prepare proposals for public investment,

(*d*) to provide and administer grants and other financial facilities for activities related to science and technology,

(*e*) to advise the Minister at his request on any matter related to science and technology,

(*f*) to promote research,

(*g*) to promote the application of science and technology to economic and social development,

(*h*) to promote the development of natural resources through the application of science and technology,

(*i*) to promote appreciation of the value of science and technology.

(2) The Agency may, subject to such conditions as the Minister may prescribe, do all such other things as arise out of or are consequential on the functions assigned to it by or under this Act.

(3) Without prejudice to the generality of *subsection (1)* or *(2)* of this section, the Agency shall have the following particular functions—

(*a*) to advise the Government on the need for the establishment of any new institution or the dissolution of any existing institution or on the need for revising the functions of any existing institution and on the nature or form of such institutions,

(*b*) to prepare and to review periodically a national programme for science and technology in consultation with relevant institutions,

(*c*) to co-ordinate activities related to science and technology,

(*d*) to promote participation in activities related to science and technology,

(*e*) to engage in such activities related to science and technology as may be approved by the Minister,

(*f*) to disseminate and promote the dissemination of literature and information relating to science and technology,

(*g*) to engage (where appropriate after consultation with the Minister for Foreign Affairs) in international activities in science and technology, including where appropriate representation of the State at conferences, meetings and seminars,

(*h*) to participate and promote participation in international collaborative projects in science and technology, and where appropriate to enter into agreements with comparable bodies outside the State, subject to the consent of the Minister and the Minister for Finance and where appropriate to consultation with the Minister for Foreign Affairs,

(*i*) to engage in studies on manpower, in consultation with the appropriate institutions, in connection with activities related to science and technology and where appropriate to promote the expansion and development of manpower for such activities,

(*j*) to undertake and assist, in consultation with the appropriate institutions, in the development and exploitation of inventions,

(*k*) to promote and organise seminars, conferences, lectures and demonstrations, whether in the State or elsewhere, relating to science and technology and related subjects,

(*l*) to promote the application of science and technology to the development and improvement of industrial and commercial design,

(*m*) to advise and assist inventors in registering and protecting their inventions.

(4) (*a*) The powers and functions conferred by statute on any institution shall be deemed not to be restricted by any provisions of this Act and in the exercise of its powers and functions the Agency shall have regard to the statutory functions of such institutions.

(*b*) The teaching functions of any educational institute, college or school shall be deemed not to be restricted by any provisions of this Act.

(5) The Agency shall not engage in or promote any activity of a primarily military relevance without the prior approval of the Government.

(6) The Minister may by order assign additional functions to the Agency after consultation with the Minister for Finance and with any other Minister of the Government appearing to the Minister to be concerned.

(7) The National Board for Science and Technology is hereby dissolved.

Science Budget.

9.—(1) The Agency shall, in relation to every financial year or such other period as may be specified by the Minister, prepare a statement, based so far as possible on the programme referred to in *section 8 (3) (b)* of this Act, and including the requirements and proposals of every institution in receipt of moneys from the State and giving the Agency's observations and recommendations on such requirements and proposals in the light of national policy for science and technology.

(2) Whenever the Agency prepares a statement pursuant to *subsection (1)* of this section, it shall be submitted to the Minister who after consultation with the Minister for Finance shall submit it to the Government.

(3) Details of the financial allocations finally approved for the financial year or period in question in respect of each institution, and an accompanying commentary by the Agency on national policy for science and technology, shall together constitute the Science Budget for the year or period in question.

(4) The Minister shall lay a copy of each Science Budget before both Houses of the Oireachtas.

Review of programmes.

10.—The Agency shall periodically conduct and publish a review of the effectiveness of the programmes provided for in the Science Budget.

Supply of information required by Agency.

11.—Any institution for which provision is made in the Science Budget shall supply to the Agency such information in such form and at such time as it may require.

Power to research.

12.—The Agency may, with the approval of the Minister, institute and conduct research into and studies on such problems relating to science and technology as it considers appropriate and may publish or disseminate the results of any such investigation as it considers appropriate.

Directives to the Agency.

13.—(1) The Minister may give the Agency such general policy directives as he considers appropriate having regard to the provisions of this Act.

(2) The Minister shall cause any directive given by him under *subsection (1)* of this section to be laid before each House of the Oireachtas within 21 days after it has been so given.

(3) The Agency shall comply with any directive given to it under this section and shall set out the directive in its annual report and shall include in its annual report an account of the actions which it has undertaken to give effect to the directive.

Limitation of expenditure on inventions.

14.—Section 43 (5) of the 1961 Act (which imposes a limitation on expenditure by the Agency without the consent of the Minister on the development and exploitation of inventions) is hereby amended by the insertion, after "the sum of five thousand pounds", of "or such greater sum as the Minister may from time to time by order prescribe".

PART III

Administration

Chief Executive.

15.—The Board of the Agency shall appoint a person to be the Chief Executive of the Agency under a contract of service on such terms and conditions as may be agreed to by the Board with the approval of the Minister and the Minister for Finance.

Disclosure by member of Board of interest in proposed contract.

16.—A member of the Board who has—

(*a*) any material or financial interest in any body corporate with which the Board proposes to make any contract, or

(*b*) any material or financial interest in any contract which the Board proposes to make,

shall disclose to the Board the fact of the interest and the nature thereof, and shall take no part in any deliberation or decision of the Board relating to the contract, and the disclosure shall be recorded in the minutes of the Board.

Membership of Houses of Oireachtas or Assembly of European Communities.

17.—(1) Where a member of the Board is—

(*a*) nominated as a member of Seanad Éireann, or

(*b*) elected as a member of either House of the Oireachtas or of the Assembly of the European Communities, or

(*c*) regarded pursuant to section 15 (inserted by the European Assembly Elections Act, 1984) of the European Assembly Elections Act, 1977, as having been elected to such Assembly to fill a vacancy,

he shall thereupon cease to be a member of the Board of the Agency.

(2) Where an officer or servant of the Agency is—

(*a*) nominated as a member of Seanad Éireann, or

(*b*) elected as a member of either House of the Oireachtas or of the Assembly of the European Communities, or

(*c*) regarded pursuant to section 15 (inserted by the European Assembly Elections Act, 1984) of the European Assembly Elections Act, 1977, as having been elected to such Assembly to fill a vacancy,

he shall thereupon stand seconded from the employment of the Agency and shall not be paid by, or be entitled to receive from, the Agency any remuneration or allowances in respect of the period commencing on such nomination or election or when he is so regarded as having been elected, as the case may be, and ending when he ceases to be a member of either such House or such Assembly.

(3) In consequence of the foregoing provisions of this section, section 13 of the Act of 1961 shall have effect as follows:

(*a*) subsections (1) and (2), paragraphs (*a*) and (*b*) of subsection (3) and subsection (6) shall cease to have effect;

(*b*) the references in subsection (3) to an officer or servant who becomes a member of either House of the Oireachtas shall be construed as a reference to a person to whom *subsection (2)* of this section applies;

(*c*) the references to secondment and secondment period in the said section 13 shall be construed as references to secondment and the period of secondment under *subsection (2)* of this section.

(4) A person who is for the time being entitled under the Standing Orders of either House of the Oireachtas to sit therein or who is a member of the Assembly of the European Communities shall, while he is so entitled or is such a member, be disqualified from becoming a member of the Board or from employment by the Agency.

Expenditure by Agency.

18.—The funds of the Agency may be used—

(*a*) for the payment of expenses incurred by it in the performance of its functions, and

(*b*) for the making of payments, grants or loans for any purpose that, in the opinion of the Agency, is conducive to the promotion and development of scientific and technological activities.

Investment by Agency.

19.—The Agency may invest any of its funds (not being funds to which *section 20 (3)* of this Act applies) in any manner in which a trustee is empowered by law to invest trust funds.

Acceptance of gifts by Agency.

20.—(1) The Agency may accept gifts of money, land or other property upon such trusts and conditions, if any, as may be specified by the donor.

(2) The Agency shall not accept a gift if the conditions attached to the acceptance by the donor are inconsistent with the functions of the Agency.

(3) Any funds of the Agency, being a gift or the proceeds of a gift to it, may, subject to any terms or conditions of the gift, be invested

in any manner in which a trustee is empowered by law to invest trust funds.

Annual report and information to Minister.

21.—(1) The Agency shall make annually, at such date as the Minister may direct, a report to the Minister of its proceedings under this Act during the period of twelve months ending on that date, and the Minister shall cause copies of the report to be laid before each House of the Oireachtas.

(2) The report submitted to the Minister pursuant to *subsection (1)* of this section shall contain such information as the Minister may direct regarding the functions of the Agency.

(3) The Agency shall supply the Minister with such information regarding the performance of its functions as he may from time to time require.

Accounts and audits.

22.—(1) The Agency shall keep, in such form as may be approved by the Minister with the consent of the Minister for Finance, all proper and usual accounts of all moneys received or expenses incurred by it and, in particular, shall keep in such form as aforesaid all such special accounts as the Minister or the Minister for Finance may from time to time direct.

(2) Accounts kept in pursuance of this section shall be submitted annually by the Agency to the Comptroller and Auditor General for audit and immediately after such audit a copy of the income and expenditure account and of the balance sheet and of such other of the accounts kept pursuant to *subsection (1)* of this section as the Minister, with the consent of the Minister for Finance, may direct and a copy of the Comptroller and Auditor General's report on the accounts shall be presented to the Minister who shall cause copies thereof to be laid before each House of the Oireachtas.

Officers and servants.

23.—(1) The Agency shall appoint such and so many persons to be officers and servants of the Agency as it may determine with the consent of the Minister and the Minister for Finance.

(2) The Agency shall from time to time determine the grades, tenure of office and conditions of service of its officers and servants.

(3) An officer or servant of the Agency shall be paid such remuneration and allowances as the Agency, with the consent of the Minister and the Minister for Finance, may from time to time determine.

Power to employ consultants.

24.—The Agency may employ such consultants or advisers on short term contracts of service as it considers necessary for the proper discharge of its functions.

Prohibition of disclosure of confidential information.

25.—(1) No person who is or has been a member of the Board or an officer or servant of the Agency, or an adviser or consultant to the Agency shall disclose any information classified by the Agency as confidential which has been obtained by him while performing (or as a result of having performed) duties as such member, officer, servant, adviser or consultant.

(2) A person who contravenes *subsection (1)* of this section shall

be guilty of an offence and shall be liable on summary conviction to a fine not exceeding £500.

Committees of Board.

26.—(1) The Board may from time to time establish committees to perform such of the functions of the Agency as, in the opinion of the Board, may be better or more conveniently performed by a committee and are assigned to a committee by the Board.

(2) A committee established under this section may, if the Board thinks fit, include in its membership persons who are not members of the Board.

(3) The appointment of a person to act as a member of a committee established under this section shall be subject to such conditions (including conditions as to terms and the tenure of office of the member) as the Board, with the consent of the Minister and the Minister for Finance, may think fit to impose when making the appointment.

(4) A member of a committee established under this section may be removed from office at any time by the Board.

(5) The Board may at any time dissolve a committee appointed under this section.

(6) The acts of a committee established under this section shall be subject to the approval of the Board.

(7) The Board may regulate the procedure of committees established under this section but, subject to any such regulation, committees established under this section may regulate their own procedure.

PART IV

Transitional Provisions

Transfer of staff.

27.—(1) A person who, immediately before the commencement of this Act, was an officer or servant of the dissolved body shall on that commencement become and be an officer or servant of the Agency on terms and conditions not less favourable than those applicable to that person immediately before that commencement.

(2) A scheme approved of under section 28 of the National Board for Science and Technology Act, 1977 for the superannuation of officers and servants of the dissolved body shall be deemed to be a scheme approved of under section 35 of the Act of 1961 and may be amended accordingly.

(3) Section 35 (1) of the Act of 1961 is hereby amended by the insertion of "or death to or in respect of " before the words "the permanent staff".

Transfer of property.

28.—(1) On the commencement of this Act all property, including choses-in-action, which immediately before that commencement was the property of the dissolved body shall stand vested in the Agency without any conveyance or assignment.

(2) Every chose-in-action transferred by *subsection (1)* of this section to the Agency may be sued on and recovered or enforced by

the Agency in its own name and it shall not be necessary for the Agency to give notice to the person bound by the chose-in-action of the transfer effected by that subsection.

Transfer of rights and liabilities and continuance of pending proceedings.

29.—(1) All rights and liabilities of the dissolved body shall on the commencement of this Act stand transferred to the Agency.

(2) Every right and liability transferred by *subsection (1)* of this section to the Agency may be sued on, recovered or enforced by or against the Agency in its own name and it shall not be necessary for the Agency to give notice to the person whose right or liability is transferred by this section of such transfer.

(3) All legal proceedings pending immediately before the commencement of this Act to which the dissolved body was a party shall be continued with the substitution for the dissolved body of the Agency.

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